

THE
RUBBER RESEARCH INSTITUTE
OF
MALAYA



ANNUAL REPORT 1937



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July 1938

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THE RUBBER RESEARCH INSTITUTE OF MALAYA

MEMBERS OF THE BOARD

at the 31st December, 1937

The Director of the Institute
(Mr. H. J. PAGE, M.B.E.)

Chairman, *ex officio*

The Hon'ble the Financial Secretary,
F.M.S.

Financial Member (appointed by the
High Commissioner under section
5 (i) (b) of the Enactment (Cap.
108)

The Hon'ble the Director of Agri-
culture, S.S. and Adviser on Agri-
culture, Malay States }

Ex officio

CHE HAMZAH BIN ABDULLAH, M.C.S.

Orang Kaya Kaya Stia Bi-jaya di-
Raja, Perak, CHE MOHAMED NOORDIN
BIN ABDUL SHUKOR, I.S.O. }

appointed by the High Commissioner
under section 5 (i) (d) of the Enact-
ment (Cap. 108)

Mr. A. P. CRANNA—on leave (Mr.
H. B. EGMONT HAKE, C.B.E.—acting)

Mr. CHOO KIA PENG, C.B.E., J.P.

Mr. D. FARQUHARSON, J.P.

Mr. J. ROBERTSON, J.P.

The Hon'ble Mr. B. J. R. BARTON. }

appointed by the High Commissioner
under section 5 (i) (e) of the Enact-
ment (Cap. 108)

THE PERMANENT COMMITTEE

The Director of the Institute

Chairman, *ex officio*

The Hon'ble the Financial Secretary,
F.M.S.

Financial Member, *ex officio*

Mr. A. P. CRANNA—on leave (Mr.
H. B. EGMONT HAKE, C.B.E.—acting)

Mr. CHOO KIA PENG, C.B.E., J.P.

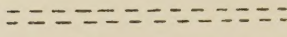
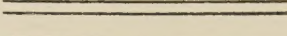
Mr. J. ROBERTSON, J.P. }

appointed by the High Commissioner
under section 13 (i) (c) of the En-
actment (Cap. 108)

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REFERENCE

Streams.....	
Roads.....	
Drains.....	

ACREAGE STATEMENT

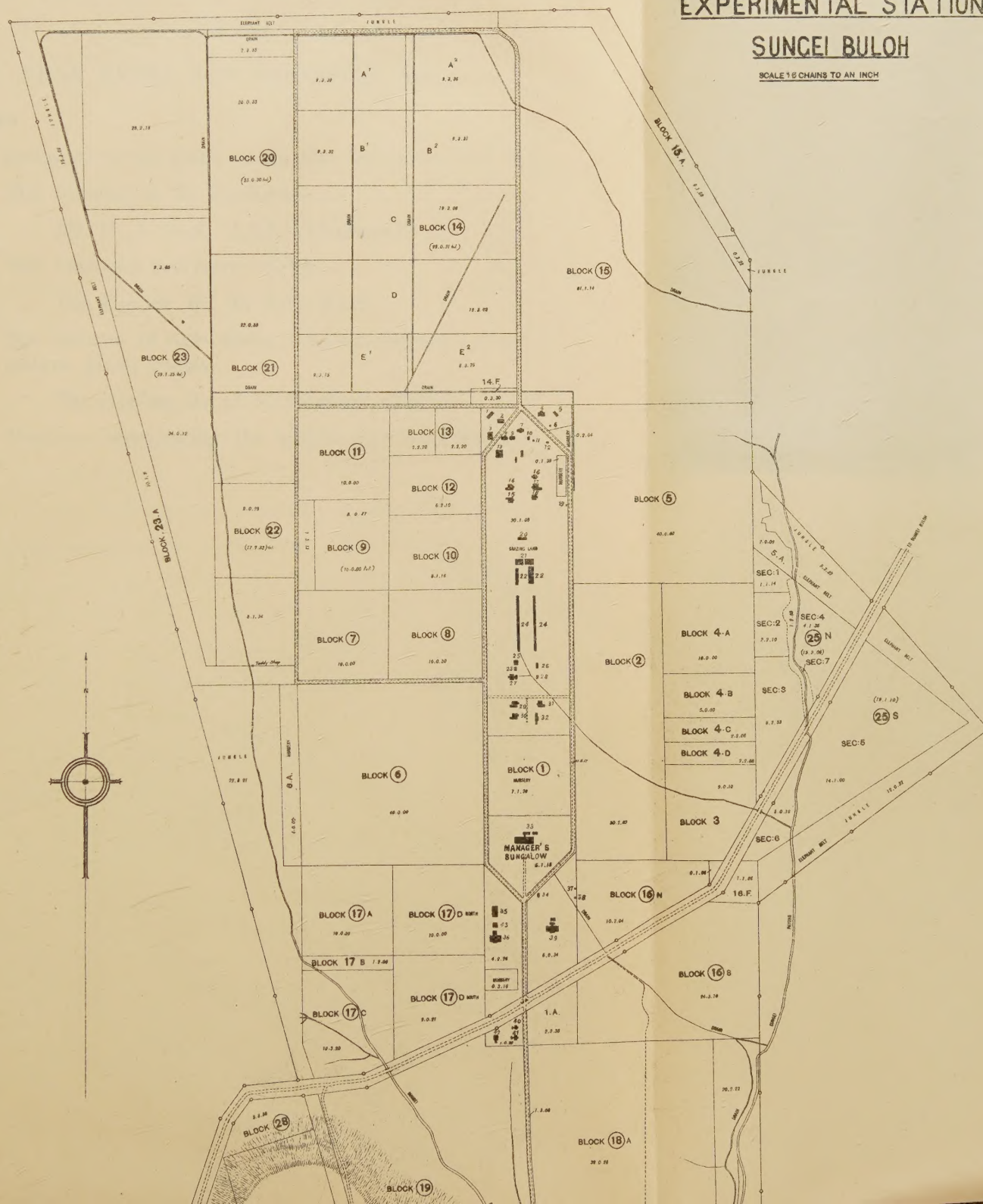
Block No.	Planted	Jungle	Building Sites	Roads	Nursery
1	—	—	50.3.11	11.0.17	9.1.07
1A	2.3.38	—	—	—	—
2	30.2.00	—	—	—	—
3	9.0.10	—	—	—	—
4A	10.0.00	—	—	—	—
4B	—	—	—	—	5.0.00
4C	2.2.08	—	—	—	—
4D	2.2.08	—	—	—	—
5	40.0.00	—	—	—	—
5A	2.0.09	—	—	—	—
6	40.0.00	—	—	—	4.0.00
7	10.0.00	—	—	—	—
8	10.0.30	—	—	—	—
9	10.0.00	—	—	—	—
10	8.1.16	—	—	—	—
11	10.0.00	—	—	—	—
12	6.2.10	—	—	—	—
13	5.1.00	—	—	—	—
14	99.0.31	—	—	—	—
15	81.1.14	0.3.22	—	—	—
15A	9.1.09	—	—	—	—
16N	10.2.04	—	—	—	—
16S	24.3.10	—	—	—	—
16F	1.3.04	—	—	—	—
17A	10.0.00	22.3.21	—	—	—
17B	1.2.00	—	—	—	—
17C	10.3.20	—	—	—	—
17 D.N.	10.0.00	—	—	—	—
17 D.S.	9.0.21	—	—	—	—
18A	39.0.28	—	—	1.3.08	—
18B	9.8.12	—	—	—	—
18C	20.2.22	—	—	—	—
19	63.1.17	—	—	—	—
20	23.0.30	—	—	—	—
21	23.0.35	—	—	—	—
22	17.2.33	—	—	—	—
23	69.1.35	15.3.02	—	—	—
23A	10.1.11	—	—	—	—
24	31.1.07	—	—	—	—
25N	15.3.06	5.3.32	—	—	—
25S	19.1.10	12.0.32	—	—	—
26	9.3.36	—	—	—	—
27	50.2.00	—	—	—	—
28	3.3.38	—	—	—	—
29	4.1.02	—	—	—	—
30	40.3.21	—	—	—	—
31	38.3.03	—	—	—	—
32	16.3.36	—	—	—	—
33	46.3.01	63.1.24	—	—	—
34	44.0.34	1.1.12	—	—	—
35	29.3.31	47.1.20	—	—	—
TOTAL	1,098.0.10	169.3.05	52.1.33	12.3.25	18.1.07

BUILDING NOS.

1	Pathology Division Shed
2	General Store
3	Bucket & Chemical Store
4	Cooly Lines
5	Kongsie
6	Filter House
7	Hostel
8	Crepe Drying Shed
9	Packing Shed
10	Kampong Smoke House
11	Devon Smoke House
12	A.P.C. Drying Shed
13	Factory
14	Conductor's Qrs.
15	" "
16	" "
17	" "
18	" "
19	Temple
20	Cattle Shed
21	Cooly Lines
22	" "
23	Creche
24	Cooly Lines
25	Shop
26	School
27	Hospital
28	Rice Store
29	Conductor's Qrs.
30	" "
31	" "
32	" "
33	Manager's Bungalow
34	New Store
35	Office
36	Guest House
37	Benzine Store
38	Engine House
39	Assistant's Bungalow
40	Conductor's Qrs.
41	A.R.I.'s Bungalow
42	Conductor's Qrs.
43	Garage
44	Assistant's Bungalow

The map of the Experiment Station is for reference in connection with the Reports of the Manager of the Experiment Station and of Heads of Divisions. A general map of Malaya appears at the end of the book.

SCALE 16 CHAINS TO AN INCH



Surveyor & Leveler
44 White Mlang Road
Kuala Lumpur.
10th Nov. 1928



REPORT OF THE BOARD

FOR THE

YEAR ENDED 31ST DECEMBER, 1937

THE BOARD

The personnel of the board at the 31st December, 1937, was

(a) The Director of the Institute—

Mr. H. J. Page, M.B.E. (*Chairman*)

(b) The Financial Secretary, F.M.S.—

The Hon'ble Mr. M. Rex, M.C.S.

(c) The Director of Agriculture, S.S., and Adviser on Agriculture, Malay States—

The Hon'ble Mr. O. T. Faulkner, C.M.G.

(d) Members representing the interests of small-holders—

Che Hamzah bin Abdullah, M.C.S.

Che Mohamed Noordin bin Abdul Shukor, I.S.O.

(e) Members nominated by Planting Associations—

* Mr. A. P. Cranna—on leave (Mr. H. B. Egmont Hake, C.B.E., acting)

* Mr. Choo Kia Peng, C.B.E., J.P.

The Hon'ble Mr. B. J. R. Barton

* Mr. J. Robertson, J.P.

Mr. D. Farquharson, J.P.

* These members served on the Permanent Committee.

Until the 20th January, 1937, Mr. H. R. Joynt (Treasurer and Financial Adviser, F.M.S.) served on the Board as Financial Member. He was followed, on the 29th January, by Mr. L. Rayman, who served until the 19th August, when the two offices of Treasurer, F.M.S., and Financial Adviser, F.M.S., formerly held by one officer, were separated, the former becoming Accountant-General, F.M.S., and the latter Financial Secretary, F.M.S. (G.N. 4085 of 20.8.37). The Financial Secretary, F.M.S. to which office Mr. M. Rex was appointed on the 20th August, became the Financial Member of the Board and served for the remainder of the year.

Mr. J. S. Ferguson was on leave from the 8th May until the 14th June.

The members appointed by the High Commissioner under Section 5 (i) (d) and (e) of The Rubber Research Institute of Malaya Enactment (Cap. 108) were appointed for a period of three years from the 15th June, 1934, and their terms of office expired therefore on the 14th June, 1937. On the 25th June, 1937, the High Commissioner, by Notification no. 3116 in the F.M.S. Government Gazette, appointed the following gentlemen to be members of the Board for a period of three years from the 15th June, 1937:—

Che Hamzah bin Abdullah, M.C.S.

The Orang Kaya Kaya Stia Bi-jaya di-Raja, Perak
(Che Mohamed Noordin bin Abdul Shukor, I.S.O.)

* Mr. A. P. Cranna

* Mr. Choo Kia Peng, C.B.E., J.P.

Mr. D. Farquharson, J.P.

* Mr. J. C. Innes, J.P.

The Hon'ble Mr. B. J. R. Barton

The members marked * were also appointed to serve on the Permanent Committee.

Mr. Choo Kia Peng was granted leave from the 10th April to the 12th September. A substitute was not appointed to the Board; Che Hamzah agreed to serve on the Permanent Committee during Mr. Choo Kia Peng's absence.

Mr. A. P. Cranna was on leave from the 30th July for the remainder of the year, during which period Mr. H. B. Egmont Hake acted for him on the Board and on the Permanent Committee.

Mr. J. C. Innes retired from Malaya in September and resigned from the Board on the 25th September, from which date Mr. J. Robertson J. P. was appointed by the High Commissioner to be a member of the Board and of the Permanent Committee for a period of three years (G.N. 4749 and 4750 of 1.10.37).

MEETINGS OF THE BOARD AND COMMITTEES

During 1937 the meetings of the Board and Committees were

Board	...	...	...	...	3
Permanent Committee	...	...	...	...	5
<i>Ad hoc</i> Committees	...	...	...	...	4
					—
					12
					—

THE REVENUE OF THE INSTITUTE

In 1937 the Institute continued to be financed via the Malayan Rubber Fund on behalf of the rubber-growers of all Malayan territories except the State of Brunei; from producers in Brunei contributions were received through the Government of Brunei. The total received in respect of the year was \$588,998.64.

NEW BUILDINGS FOR THE INSTITUTE

The new buildings on Ampang Road, Kuala Lumpur, were ready for occupation early in 1937, and all the equipment from the old buildings was transferred during the first half of March. On the 19th May the buildings were officially opened by His Excellency the Governor of the Straits Settlements and High Commissioner for the Malay States, Sir Thomas Shenton Whitelegge Thomas, G.C.M.G., O.B.E.

ACCOUNTS FOR THE YEAR 1937

Subjoined are the Income and Expenditure Account for the year 1937 and the Balance Sheet as at the 31st December, 1937.

The income for the year was—

Contributions from rubber-growers, via Administrations ...	\$ 588,998 64
Interest on investments and bank balances, Sales of rubber and publications etc., House rentals	61,613 56
	\$ 650,612 20

Expenditure was—

Normal	...	...	...	\$ 598,363 96
Special:				
Land for small-scale replanting experiments	...	...	\$ 7,706 00	
Improvements to land on which new buildings are erected	...	2,403 98		
Additions to new buildings	...	33,188 92		
Plant and Machinery	...	13,695 45		
Furniture for houses	...	1,354 00		
Furniture for offices and laboratories	...	3,835 32		
Apparatus	...	9,118 90		
Experiment Station Development		27,203 72	98,506 29	
			\$ 696,870 25	

Part of the expenditure on furniture, apparatus, glassware and machinery was to replace material lost in the fire of September, 1936; this expenditure was met from the compensation received in 1936 from the Insurance Company.

From the balance sheet it will be observed that the total excess of assets over liabilities is \$1,396,869.17, represented by

Buildings and Land (Staff houses)	...	\$314,222	25
Buildings and Land (Institute)	...	257,777	57
Land, other than the Experiment Station, for experimental purposes	...	8,534	69
Furniture (Staff houses)	...	21,092	03
Furniture (Institute)	...	15,139	81
Plant, Machinery and Apparatus	...	61,170	79
Experiment Station	...	481,508	27
Stocks	...	3,542	40
Sundry Debtors	...	66,716	16
Investments	...	163,012	12
Cash	...	109,013	13
		\$1,501,729	22
<i>Less</i> Sundry Creditors (miscellaneous)		\$46,068	30
Reserve for staff leave-pay and passages	...	52,161	61
Rubber Roadways Committee— balance of grant from the Rubber Experimental Research and Pro- paganda Fund	...	6,630	14
		\$1,396,869	17

The realisable investments (at cost) and available cash amount to \$234,125.

SMALL-HOLDERS' ADVISORY SERVICE

At the commencement of 1937 the approved establishment of Asiatic Rubber Instructors in the Service was 24, and 19 were on duty. During the year five more Instructors were appointed.

A review of the progress of this Service since its inception in 1934 shows that there has been great improvement in the quality of sheet rubber produced by small-holders, but much remains to be done in this direction. It is desirable also to stimulate interest in tapping, budgrafting, manuring, disease treatment and replanting. In order to educate the small-holders in these matters the Board has decided to increase the number of

Instructors and it is planned to double the establishment of the Service during the next five or six years. In addition it has been decided to appoint a whole-time officer to visit the Instructors regularly at their stations and generally to supervise their work.

ACTIVITIES OF THE INSTITUTE IN 1937 AND 1938

The latter half of 1937 has seen the Institute recovering from the disorganisation caused by the fire in September 1936 and the removal into the new premises.

The Institute is supervising and co-operating in the establishment and conduct of over one hundred experiments on estates in different parts of the Peninsula comprising a total area of about 8,000 acres of land which, by the provisions of the International Rubber Regulation Agreement, may be planted for experimental purposes. The work involved in the planning and laying down of these experiments has entailed additions to the staff.

A further improvement that it is hoped to make in 1938 is the development of an organisation for making more generally and easily available to producers the information that is being amassed from experimental work being conducted by or under the aegis of the Institute, with special reference to facilitating its practical application.

Additions to the scientific staff, approved late in 1936, and made during 1937, consisted of two Botanists, one Soils Chemist, one Statistician. A Junior Assistant for the Experiment Station was also appointed.

H. J. PAGE

Chairman of the Board

H. S. BLACKLIN

Secretary

Kuala Lumpur,

24th February, 1938.

INCOME AND EXPENDITURE ACCOUNT

Dr.

EXPENDITURE

	\$	c.	\$	c.
To Experiment Station			102,758	90
„ Board and Committees (Fees and Expenses) ...			1,881	89
„ London Advisory Committee			22,400	00
„ London Secretarial Expenses			32	22
„ Salaries and Allowances			235,355	55
„ Provident Fund			21,384	77
„ Staff Leave Pay and Passages			31,462	00
„ Rubber Roadways Research			8,533	33
„ Medical			3,868	45
„ Travelling			15,255	62
„ Office General Charges (Printing, Stationery, Postage, Telephone, Audit and Legal) ...			7,279	37
„ Staff Recruiting			782	49
„ Rents, Rates and Insurance			3,422	91
„ Laboratory General Charges			1,609	25
„ Maintenance: Buildings (Offices and Residential Houses)			6,350	48
„ Maintenance: Laboratory Grounds			1,797	93
„ Laboratories and Offices Cleaning Expenses ...			682	83
„ Repairs and Renewals Furniture and Office Equipment			9,320	08
„ Repairs and Renewals Fixtures and Fittings ...			3,232	78
„ Plant and Machinery (Repairs and Running Expenses)			2,609	22
„ Power, Lighting, Water and Sanitation			4,797	09
„ Lorry (Running Expenses)			2,251	99
„ Workshop			691	70
„ Laboratory Apparatus and Glassware			22,725	64
„ Laboratory Chemicals			3,504	34
„ Publications issued by the Institute			4,757	50
„ Library (New Books, Subscriptions to Periodicals and Sundries)			5,921	77
„ Exhibitions and Demonstrations			1,680	22
„ Small Holders' Advisory Service:				
Film Propaganda	1,618	52		
Asiatic Rubber Instructors	35,622	14		
Experiments on small-holdings	1,403	61		
Grant to Department of Agriculture for Vernacular Publications	2,000	00	40,644	27
„ Removal expenses and opening ceremony expenses			2,184	44
„ Experiments (Field and Testing Laboratory) ...			29,184	93
„ Depreciation for year			73,172	24
			<u>\$671,536</u>	<u>20</u>
To Balance being Excess of Expenditure over Income for the year brought down			17,786	60
„ Contribution overpaid by the Malayan Rubber Fund in 1936, deducted from 1937 Contribution			3,137	40
			<u>\$20,924</u>	<u>00</u>

KUALA LUMPUR,
7th February, 1938

FOR THE YEAR ENDED 31st DECEMBER, 1937

Cr.

INCOME

	\$	c.	\$	c.
By Contributions by Administrations for the year ...			592,136	04
„ Interest on Cash and Investments			6,647	00
„ Miscellaneous Receipts:				
Sales of Rubber	48,466	01		
Sales of Publications	1,172	92		
House Rentals	3,628	00		
Proceeds of sale of old boiler and gas plant \$550 00				
Proceeds of sale of old well and pump 150 00	700	00		
General	999	63	54,966	56
„ Balance being Excess of Expenditure over Income for the year carried forward			17,786	60

\$671,536 20

By Balance being Excess of all Expenditure over
Income carried to Balance Sheet 20,924 00

\$20,924 00

(Sgd.) H. S. BLACKLIN
Secretary

(Sgd.) H. J. PAGE
Chairman of the Board

31st DECEMBER, 1937

ASSETS

				\$	c.	\$	c.
LAND AND BUILDINGS :							
132 Ampang Road							
Land as at 1.1.37	...	...		10,755	00		
Ampang Villa as at 1.1.37	...	...	13,711	47			
Less Depreciation for year	...	...	1,523	49	12,187	98	
132a Ampang Road Building							
As at 1.1.37	...	...	31,167	43			
Less Depreciation for year	...	...	3,463	02	27,704	41	50,647 39
Land behind Ampang Villa							
As at 1.1.37	...	...					5,029 35
5 Circular Road :							
Land as at 1.1.37	...	...			17,147	08	
Old Building as at 1.1.37	...	...	10,679	93			
Less Depreciation for year	...	...	1,186	66	9,493	27	
Three houses as at 1.1.37	...	...	56,406	81			
Less Depreciation for year	...	...	6,267	42	50,139	39	76,779 74
163 Ampang Road :							
Land as at 1.1.37	...	...			31,440	35	
Old Building as at 1-1-37	...	...	9,917	23			
Less Depreciation for year	...	...	1,101	91	8,815	32	
Five houses as at 1-1-37	...	...	66,482	24			
Less Depreciation for year	...	...	7,386	91	59,095	33	99,351 00
184/8 Ampang Road :							
Land as at 1.1.37	...	...			27,582	50	
Five houses as at 1.1.37	...	...	61,206	93			
Less Depreciation for year	...	...	6,374	66	54,832	27	82,414 77
Land on Ulu Klang Road	...	...					7,705 00
Land on Ampang Road under lease					932	40	
Add additions during year	...	...			1	00	
					933	40	
Less Depreciation for year	...	...			103	71	829 69
LABORATORY BUILDINGS (DAMANSARA ROAD) :							
As at 1st January 1937	...	...			1	00	
Less Depreciation for year	...	...			1	00	
LABORATORY BUILDINGS & LAND (AMPANG ROAD) :							
Land as at 1.1.37	...	...	19,440	00			
Add Cost of Improvement	...	...	2,403	98	21,843	98	
Building as at 1.1.37	...	...	224,774	39			
Additions during year	...	...	33,188	92			
			257,963	31			
Less Depreciation for year	...	...	22,029	72	235,933	59	257,777 57
Carried forward						580,534	51

BALANCE SHEET AS AT**LIABILITIES—***(Contd.)*

	\$	c.	\$	c.
Brought forward ...			1,501,729	22

Carried forward ...			1,501,729	22
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31st DECEMBER, 1937 (Contd.)

ASSETS—(Contd.)

		\$	c.	\$	c.
Brought forward	...			580,534	51
PLANT AND MACHINERY:					
Electric Plant as at 1.1.37	...	972	78		
Less Depreciation for year	...	971	78	1	00
General Machinery as at 1.1.37	...	14,948	29		
Add additions during year	...	13,695	45		
		28,643	74		
Less Depreciation for year	...	2,242	24	26,401	50
				26,402	50
FURNITURE:					
Residential Houses:					
As at 1.1.37	...	21,931	14		
Add additions during year	...	1,354	00		
		23,285	14		
Less Depreciation for year	...	2,193	11	21,092	03
Offices:					
As at 1.1.37	...	7,173	58		
Add additions during year	...	499	05		
		7,672	63		
Less Depreciation for year	...	717	36	6,955	27
Laboratories:					
As at 1.1.37	...	4,739	51		
Add additions during year	...	3,054	02		
		7,793	53		
Less Depreciation for year	...	473	95	7,319	58
Library:					
As at 1.1.37	...	647	46		
Add additions during year	...	282	25		
		929	71		
Less Depreciation for year	...	64	75	864	96
				36,231	84
LABORATORY APPARATUS AND GLASSWARE:					
As at 1.1.37	...			31,148	66
Add additions during year	...			9,118	90
				40,267	56
Less Depreciation for year	...			6,229	73
				34,037	83
MOTOR LORRY:					
As at 1.1.37	...			484	34
Less Depreciation for year	...			121	08
					363 26
WORKSHOP EQUIPMENT:					
As at 1-1-37	...			432	00
Less Depreciation for year	...			64	80
					367 20
R.R.I. EXPERIMENT STATION:					
Development Expenditure as at 1-1-37	...			464,959	49
Add additions during year	...			27,203	72
				492,163	21
Less Depreciation for year	...			10,654	94
				481,508	27
Carried forward	...			1,159,445	41

BALANCE SHEET AS AT

LIABILITIES—*(Contd.)*

	\$	c.
Brought forward ...	1,501,729	22

Carried forward ...		
---------------------	--	--

	1,501,729	22
--	-----------	----

31st DECEMBER, 1937 (Contd.)

ASSETS—(Contd.)				\$	c.	\$	c.
Brought forward ...						1,159,445	41
LIBRARY BOOKS AND PERIODICALS :							
As at 1.1.37	...	...	...		1	00	
Add Purchases during year	...	...	...		3,474	02	
						3,475	02
Less written off	...	...	...		3,474	02	1 00
STOCKS :							
Petrol and Oil :							
Laboratory	...	...	258 55				
Experiment Station	...	...	23 91		282	46	
Empty Drums and Containers :							
Laboratory	...	...	179 50				
Experiment Station	...	...	117 50		297	00	
Stationery					887	44	
Sundry Materials :							
Laboratory	...	...	500 95				
Experiment Station	...	...	1,573 55		2,074	50	3,541 40
SUNDRY DEPOSITS (For Water, Telephones etc.) :							
Laboratory	...	...	...		235	00	
Experiment Station	...	...	...		20	00	255 00
SUNDRY DEBTORS :							
Administrations	...	...	...		41,829	67	
Staff	...	...	...		21,378	20	
Accrued Interest	...	...	...		650	00	
General	...	...	...		262	83	
At Experiment Station	...	...	...		274	15	64,394 85
SUSPENSE :							
Laboratory	...	...	...		93	28	
Experiment Station	...	...	...		1,925	24	2,018 52
INVESTMENTS AT COST :							
4½% Singapore Municipal Loan							
Nominal value \$15,000/-	...	...	...		17,536	69	
British 3½% War Loan, 1932/52							
Nominal value £17,000	...	...	...		145,475	43	163,012 12
ADVANCE PAYMENTS						47	79
CASH AT BANK AND IN HAND :							
Chartered Bank, London	...	...	...		5,570	61	
Chartered Bank, Kuala Lumpur :	...	...	...				
Board's Account	...	...	394 21				
Rubber Roadways Committee	...	...	6,630 14				
Working Account	...	...	91,351 47				
Experiment Station	...	...	4,360 01		102,735	83	
Carried forward					108,306	44	1,392,716 09

BALANCE SHEET AS AT**LIABILITIES—(Contd.)**

	\$	c.	\$	c.
Brought forward ...			1,501,729	22

(Sgd.) H. S. BLACKLIN
Secretary

(Sgd.) H. J. PAGE
Chairman of the Board

\$1,501,729 22

I hereby certify that to the best of my knowledge and belief all
 Kuala Lumpur,
 7th February, 1938

We have audited the above Balance Sheet and Income and Expenditure
 Malaya, and certify same to be correct according to the best of our information

Kuala Lumpur,
 1st March, 1938

31st DECEMBER, 1937 (*Contd.*)**ASSETS—**(*Contd.*)

				\$	c.	\$	c.
Petty Cash :	Brought forward	...		108,306	44	1,392,716	09
Secretary	...	...	207	29			
Imprest Advance	...	...	70	00			
Experiment Station	...	...	429	40	706	69	109,013 13

 \$1,501,729 22

liabilities to 31st December, 1937, have been brought into account.

(Sgd.) H. S. BLACKLIN
Secretary

Account with the books and vouchers of the Rubber Research Institute of
 and the explanations given to us and as shown by the books of the Institute.

(Sgd.) GIBSON, ANDERSON, BUTLER & CO.
Chartered Accountants
Auditors

ANNUAL REPORT

OF

THE DIRECTOR

Introduction

The years 1936 and 1937 were both years of transition and development for the Institute. In 1936 the erection of new buildings was commenced; these were completed and equipped early in 1937, and were fully occupied by the end of March. I became Director in August 1936, so that the year now under review was the first complete year of my tenure of office.

A plan for further developing the activities of the Institute was formulated towards the end of 1936 and developed in 1937; this is a "two-year plan" designed to give to the Institute by the end of 1938 the complete organisation considered necessary in order that the Malayan rubber-producing industry should receive the fullest practicable service, by way of research and advice, that it is entitled to expect. Only in one respect—the expansion of the Small-Holders' Advisory Service—is it expected that a longer period will be needed to complete the plan. The increased expenditure necessary to give effect to the first of the two stages of this plan was approved by the Board in November 1936, and this first stage was brought into effect during 1937. In November 1937 the Board approved the further increase in expenditure necessary to implement the second and final stage of the plan during 1938. Reference to the individual features of this plan, and to their fulfillment, actual or projected, in 1937 or 1938 respectively, is made in the appropriate sections of this report.

The total contributions received from the Malayan rubber-producing industry, through the Malayan Rubber Fund (and direct from Brunei) in 1937 represented 7.24 cents per pikul of the exportable quota for that year, as against the 10 cents per pikul to which the Institute is entitled by resolution of the Federal Council, and similar arrangements in the other Malayan Administrations. The estimated expenditure for 1938, as approved by the Board in November 1937, involves a contribution which would represent the full 10 cents per pikul of rubber exported, at an average release for the year of 67% of the Malayan basic quota. After the completion of the second stage of the plan at the end of 1938, further increases in annual expenditure will be only relatively small, arising mostly from normal increments in salary of staff, and the like. Thus, except in years when the average export release is less than about two-thirds of the

Malayan basic quota, the assured income of the Institute, on the present basis, is adequate for its effective working on the fully developed scheme now provided for.

STAFF

Additions to the scientific staff, both to fill vacancies in the existing cadre, and to add to that cadre, were made in the year under review. These consisted of two botanists, a soils chemist, and a statistician. A junior assistant at the Experiment Station was also appointed. These men took up their duties during the last five months of the year—two in August, one in October and two in November—so that the benefits of this extra staff, to the work of the Institute, were not fully obtained before the end of the year. The post of personal assistant to the Director was also created, and filled by transfer of a member of the staff of the Chemical Division, thus causing a vacancy for a chemist which had not yet been filled at the end of the year. One officer of the Chemical Division was on home leave until the end of July. Details of the above staff matters are shown in an appendix to this report.

Various additions to and changes in the Junior Staff occurred, mostly as a result of bringing the cadre of clerical and administrative staff, laboratory assistants and attendants, and field conductors, up to the larger number needed by the increased scientific staff. The number of Junior Staff increased from 99 to 135 during the year.

Two further additions to the scientific staff were approved by the Board in November 1937, to be made in 1938, namely: a small-holdings advisory officer, and an officer for work in connection with publications, scientific literature and the like. It was also decided to increase the Small-Holders' Advisory Service to about double its present size, over a period of five years, by the appointment of more Asiatic Rubber Instructors; five to be appointed in 1938.

In 1934 the title of the officer in charge of a Division was changed from "Head" to "Senior Chemist," "Senior Botanist," etc. In 1937 the former title of "Head of Division" was resuscitated.

A Staff Committee, consisting of the Heads of Divisions, the Manager of the Experiment Station, the Secretary, and the Personal Assistant to the Director, with the Director as chairman, was constituted early in 1937. It meets monthly, and assists me in a consultative capacity in matters which are the joint interest of the different sections of the Institute represented, or which affect the Institute as a whole.

NEW BUILDINGS

The new buildings of the Institute were officially opened by His Excellency the Governor of the Straits Settlements and High Commissioner for the Malay States, Sir Thomas Shenton Whitelegge Thomas, G.C.M.G., O.B.E. on 19th May, 1937, in the presence of a representative gathering numbering about 450. With the exception of the vulcanising and mixing machinery and some of the testing apparatus in the Chemical Division, which were not delivered until late in the year, and of the steam supply, all laboratories and offices were fully equipped and in full working order at the time of the official opening. The accommodation

Relative amounts of time spent on research and on advisory work by the scientific staff of the Institute in 1937

Division	Number of Officers		Percentage of time devoted to :—	
	Jan.	Dec.	Research & Experimental work	Advisory work
Botanical :				
All scientific officers -	5	7	80	20
*Research officers only -	3	5	69	31
Chemical :				
All scientific officers -	5	5	64	36
*Research officers only -	4	4	63	37
Pathological :				
All scientific officers -	3	3	63	37
*Research officers only -	2	2	47	53
Soils :				
All scientific officers -	3	4	62	38
*Research officers only -	2	3	50	50
Whole Institute :				
All scientific officers -	18	23	67	33
*Research officers only -	13	18	57	43

* "Research Officers" are all non-Asiatic graduate officers.

and equipment are incomparably better than when the Institute was in its old, temporary, quarters on the Damansara Road, and are now worthy of the Institute and of the industry which it serves. The vastly improved conditions and facilities can but react most favourably on the efficiency and quality of the research and advisory work.

RELATIVE AMOUNTS OF RESEARCH AND ADVISORY WORK

The research and advisory work of the Institute are dealt with individually later in this report. It is a matter of some interest and importance to ascertain the relative proportions which these two sections of the work of the Institute make up, in its total activities. It is possible to make an estimate of this from the monthly reports submitted to me by Heads of Divisions; these are based on the daily "logs" kept by all scientific officers, in which are recorded the approximate amounts of their time which have been devoted to matters concerning research and advisory work respectively. An analysis of these reports for the year 1937 has given the results shown on the opposite page.

It will be seen that, taking the Institute as a whole, the scientific staff in 1937 devoted two-thirds of its time to research and experimental work, and one-third of its time to advisory work. Considering only "Research Officers," the proportions are rather less than three-fifths to research and rather more than two-fifths to advisory work. The data for individual Divisions are referred to separately in discussing the work of those Divisions later in this report.

In studying the figures in detail it should be noted that the proportion between the time spent on research work and advisory work, in the Botanical, Chemical and Soils Divisions, differs from the normal to an unknown extent owing to the fact that each of these Divisions was short of its full complement of staff for the greater part of the year.

The figures for Research Officers differ from those for "all scientific officers," which include Asiatic Graduate Assistants, because the latter work directly under the supervision of Research Officers, and may in some cases (*e.g.*, Botanical Division) be almost wholly occupied with work in connection with the programme of research and experimental work. It may be noted that the Research Officers of the Botanical, Chemical, Soils and Pathological Divisions devoted an increasing proportion of their time to advisory work, in that order. It should also be noted that advisory work to small-holders is included only to a minor extent in the above data; such advisory work is carried out mainly by the special staff of Asiatic Rubber Instructors in the Small-

Holders' Advisory Service, which is dealt with separately later in this report.

These figures are presented without any attempt to conclude whether they indicate that the division of time between the two functions—research and advisory—is as it should be or not. I know of no criteria regarding the proper proportion that should exist between these functions—indeed, there can be no valid criterion save one that is determined specifically for the actual circumstances of the Institute and the industry which it serves. Data of this kind are of use in helping such a criterion to be determined. Those here presented must be regarded as primarily for information. They will be of use in other directions in conjunction with those for the next few years.

Straightforward advisory work, in connection with specific requests for advice, other than for small-holdings, is dealt with by means of correspondence, interviews at the Institute, and visits to estates, together with laboratory work (analysis of samples, examination of specimens, and so on); in so far as the requests for advice are properly within the province of the Institute, they must be answered with as little delay as possible. The actual amount of time which must be devoted to such advisory work is thus largely out of our control, and is determined by the volume of enquiries received.

It remains to be seen whether, with the full complement of officers available in Divisions in 1938, the volume of requests for advice will leave an adequate amount of time to be devoted to research work. It must be remembered that a full programme of research and experimental work covering all important problems of the industry in Malaya must be actively pursued, for it forms the basis on which the advisory work must be founded, and without which the advice given cannot be as up-to-date and reliable as it should be. Should the amount of time available for research ultimately prove to be insufficient, there are other directions in which a remedy might be sought, apart from the obvious but not necessarily practicable one of engaging additional research officers. Thus, it may be necessary to re-consider the arrangements for dealing with requests for advice, and to adopt a more stringent standard for deciding whether the question at issue is properly within our province. Again, arrangements for international co-operation in research, among producing countries in the East, might be so developed as to allow an allocation of work on problems which are common to those countries, thereby lightening the research programmes of the individual organisations. Matters bearing on both of these possibilities are discussed later in this report.

In its broadest sense the advisory work of the Institute includes all activities which have as their aim the dissemination of technical knowledge to the rubber-grower. Thus, in addition to straight-forward advisory work arising out of specific enquiries, the more generalised advisory work in the form of lectures, publications, and the like, comes under this heading. This important type of work is usually known by the ambiguous word of rather doubtful reputation—"propaganda"—when it is carried out by a commercial firm; when carried out by an official organisation such as this Institute, there is no one really satisfactory name for it; "extension work" is the term commonly used in the U.S.A., where it is widely developed, and for lack of a better name this term will be used in this connection in this report. This aspect of the Institute's work is capable of considerable expansion. Such expansion is a feature of the second stage of the "two-year plan" referred to at the beginning of this report, and the proposals therefor are dealt with as part of the next section of this report.

Advisory Work: General

The ADVISORY side of the Institute's work falls into three categories:

First, there is the provision of TECHNICAL ADVICE TO INDIVIDUAL ESTATES in response to specific enquiries.

Second, there is what may be called, to use the American term, "EXTENSION WORK," namely the dissemination of technical information to the Malayan rubber-planting industry in general.

Third, there is the SMALL-HOLDERS' ADVISORY SERVICE.

With regard to the first, the Institute now has at its disposal the necessary technical facilities for the provision of such advice promptly. The Botanical, Chemical and Soils Divisions now have each one Research Officer a major part of whose job it is to provide such advice, within the province of his Division, by correspondence or by visits. The other officers of a Division are not entirely freed from such work, but, except for the Head of the Division, they undertake it only in cases where, because of the special nature of the matter at issue, or for other reasons, it is desirable that they should do so. In their case such work comprises a relatively minor part of their duties; it is desirable in their own interests that they should undertake a certain amount of it, in order to keep them up-to-date in their knowledge of the practical estate aspects of their own special branches of research work. In the Pathological Division the two Research Officers deal

one with pests and diseases of the root-system and the other with above-ground pests and diseases and bacteriological questions. Each officer deals with advisory work in his own sphere, along with his research work therein.

One respect in which there is scope for improvement arises from the fact that a certain proportion of the enquiries deal with matters that are common knowledge to *any* technical officer who is reasonably familiar with the work of the Institute and with current scientific knowledge of rubber-production. It is often a waste of the time of a specialised scientific officer of a Division to have to prepare the answers to such enquiries himself. It is hoped to make arrangements for Research Officers of Divisions to be relieved of these more routine aspects of this work.

It is sometimes a matter of some difficulty to decide whether an enquiry is strictly within the province of this Institute, or whether it is not more properly the job of the estates' Visiting Agent. It also happens occasionally that the advice of the Institute is sought on a matter regarding which advice, perhaps unwelcome, has already been given by the V.A., without our being made aware of the latter fact. Although economic and commercial factors must necessarily be taken into account by us in the technical advice which we give, it is not our province to advise on matters which are governed mainly by such considerations, save on the subsidiary technical factors which may be involved. Moreover, special local conditions known to the manager of the estate, and to the V.A., may often make it necessary to modify the advice that an R.R.I. officer would otherwise give, and it is essential that he should be informed of such factors when his advice is sought. It may become necessary in the future to attempt a more rigid definition of the boundary between the advisory functions of the Institute and those of V.As. In the meantime, I shall always welcome cordially anything which improves the already good relations between V.As. and the Institute and which makes for closer co-operation.

"EXTENSION WORK"

The "EXTENSION" aspect of the Institute's advisory work is, in my opinion, the part of the Institute's activities for which there is now most scope for development.

The dissemination of the results of scientific research, and of scientific knowledge generally, among the industry for which it is intended, in a form in which it can be readily understood and utilized, is a perennial problem of applied industrial research of all kinds. It is not sufficient simply to publish scientific papers and technical articles and bulletins, which must be couched largely

in more or less specialised language; the practical man must also be approached, both in print and by word of mouth, in relatively non-scientific language, and above all, in the language of the industry. It is not fair to expect the scientific research officer to be able to do such work at its best; it is out of his proper sphere, unless he happens to have had practical experience in the industry as well as scientific training and experience, and unless he happens to possess the faculty—comparatively rare among scientists—of being able to describe scientific work and facts in simple non-technical language. He is engaged first and foremost as a scientist, to do scientific work:—to provide the goods for others to distribute.

A manufacturing firm does not employ its technical production staff to distribute and sell its goods; it realises that it wants an entirely different type of man for the latter job. The analogy with this Institute is cogent, if not pressed too far.

The Institute employs twenty-one scientists primarily for the conduct of scientific experimental work on the practical problems of rubber-production. Six of these give a major part of their time to advisory work on the more specialised technical aspects of these problems. It is true that these scientists are selected not merely on their academic qualifications, and that they must be ready and able to familiarise themselves with the practical aspects of the industry to the benefit of which their work is directed, but the fact remains that they are employed primarily as scientists to do scientific work. Against these twenty-one, the Institute employs three other scientists—myself and two others—for duties which involve their giving all their time to administrative work—the administration and direction of the scientific work of the 21 scientists, the control of the general organisation and running of the Institute, and the administration of the Small-Holders' Advisory Service. No special provision has been made hitherto for the proper development of an "extension" service.

The full scope of the "extension" service which I consider that this Institute should give to the industry is the following:—

- (a) The publication of the Institute's Journal, of its Annual Report, and of technical planting manuals and the like.
- (b) The issue of a "Planters' News-letter."
- (c) The publication of an Annual Review of the progress of scientific knowledge of rubber-production.
- (d) The giving of Lectures at suitable centres.
- (e) The holding of Conferences on important practical planting topics.
- (f) Radio-broadcasts to planters.

At the present time only (a) and (d) are available. With regard to (a), it should be noted that henceforth copies of the Institute's publications are being sent not only to the managers of estates, but also to the assistants.

A fair number of LECTURES, usually under the aegis of a local Branch of the Incorporated Society of Planters or of a local Planters' Association, are given by the scientific staff. Improvements in this respect are now possible with the existing organisation, with our full quota of officers for advisory work by Divisions. Research officers not primarily engaged on advisory work are rightly averse from having to give so many lectures that their scientific work is hindered; on the other hand, I always insist on research officers doing a modicum of such lecture work, (provided they are reasonably competent lecturers), as much in their own as in the planters' interests, because it is good for them to have to explain publicly and in relatively simple non-scientific language, their own work and subject.

The remaining headings above, (b), (c), (e) and (f), represent new activities.

The MONTHLY NEWS-LETTER under (b) will be, in my view, a most valuable means of keeping planters abreast with, and interested in, the Institute's work, and supplied with the latest technical information on current topics of interest to the planting industry. The material published in the Journal is of varied appeal, since it records all results of the Institute's scientific work, whether of immediate interest or of a more fundamental nature, and often necessarily in specialised scientific language. The Journal is intended more as a source of reference, as well as to put the Institute's work in its rightful place in the world's agricultural research literature. The News-letter will be a more ephemeral publication, to appeal to the generality of planters, and dealing, in every-day language, with such matters as are of outstanding interest at the moment—drawing not only on the Institute's own work, but also on information obtained from technical publications in other countries (notably the N.E.I.), from our advisory correspondence, and from the travels of the staff about the peninsula and abroad. Incidentally, it will provide a more suitable medium for correcting wrong statements or false opinions which appear sometimes in the daily press, as compared with the only means at present available, *viz.*, articles or letters from the Institute in the press. It will be issued only to planters, *i.e.*, to the industry to which the Institute belongs, and to other selected individuals; and with full copyright restrictions.

The ANNUAL REVIEW under (c) will consist of a survey of all published technical information on the subject of rubber-production

which marks a real advance in useful knowledge. No such annual review is at present available in the English language—nor, so far as I know, in any other language—though similar annual reviews in other branches of applied science are regular and valued features of their literature. It is part of the normal work of this Institute for scientific officers to peruse all scientific and technical periodicals dealing with rubber-production and cognate subjects, and for suitable abstracts or index-references to be made and kept for reference. This work is not done as efficiently as it might be, at present, owing to the scarcity of knowledge of foreign languages—notably Dutch, German and French—among the staff, and owing to the lack of a technical officer to look after the central indexing or filing of references and abstracts. Improvement in this respect will make it an easy matter to collate and summarise the useful information in the technical papers and articles published during the year.

The CONFERENCES referred to under (e) are intended as a development of the lecture arrangements already mentioned. The intention is to hold at suitable, probably irregular, intervals, perhaps twice a year, R.R.I. PLANTERS' CONFERENCES, at Kuala Lumpur or other big centre, at which some really important subject of great current interest will be discussed from all angles—scientific, practical, economic. Subjects such as “Forestry: the pros and cons of natural and other covers”; or “Replanting and Manuring: their relative places in the improvement of rubber areas”; or “Soil Erosion and its control” are mentioned here merely as examples of the kind of topic in view. Papers will be read by selected planters who are specially qualified to speak on the subject at issue—with representatives of opposing views if possible—and by scientific men—R.R.I. staff and others. It is believed that such conferences will help greatly in clarifying and crystallising opinions and experience on planting problems of great importance and uncertain solution, besides being of great value to the Institute in improving its knowledge of the practical aspects and relative economic importance of the problems on which it is working. Both at these conferences and at lectures, use will be made of cinematograph films and slides whenever feasible.

With regard to the reference to broadcasting under (f), nothing useful can be done in this direction until Malaya has a better broadcasting system. There is reason to believe that the situation in this respect will improve in the near future.

It may be thought that the above proposals savour of window-dressing; and so they do to some extent. It is the job of the Institute to “sell” its services to the industry—or rather to see that the industry gets full value for which it pays.

If the whole industry was already actively using the services which the Institute can afford, there would be no need for some of the measures proposed (though others would still be needed). In actual fact, however, the estates which voluntarily solicit the help and advice of the Institute represent only a proportion of the total. There are in British Malaya 2,415 estates of over 100 acres. The number of estates with which the Institute has been in correspondence on technical matters during 1937, as shown by our correspondence files, is less than half of this number. The remainder are reached at present only by our publications or by attendance of their staff at our lectures.

It might be argued that if estates do not trouble to ask us for help, we have no further obligation to them, but with this I strongly disagree. The Institute must try to improve the efficiency, and thus the prosperity, of the whole Malayan rubber-producing industry; those who do not voluntarily use the Institute for this purpose must be stimulated to improve their efficiency, in the interests of the Malayan industry as a whole, by activities originated by the Institute. The activities I have outlined here represent the steps which I feel the Institute must take for this purpose, and for improving the service which it already gives to the others.

The appointment of a full-time Small-Holdings Advisory Officer will release a part of the time of my personal assistant, which will be devoted to work in connection with these proposed new activities, but will not nearly suffice for the whole of them. One more full-time appointment is needed, and has been approved by the Board. A man with a good scientific training, a knowledge of languages, together with some knowledge of the rubber-producing industry will be sought for this appointment.

In concluding this section of my report, I quote extracts from recent publications in England, the United States, and Australia, which illustrate the world-wide nature of the problems of "extension work," and that the essentials of these problems are similar throughout.

From "Nature," Vol. 141 (1938), p. 430, in the editorial dealing with the report of the Department of Scientific and Industrial Research (of Great Britain):—

"The first need to-day is probably for a greater response and willingness to co-operate on the part of the scientific worker himself."

"Much is indeed involved in such co-operation. In the first place, there is still far too much jargon and loose expression in scientific or technical papers. It is true, of course, that the scientific investigator is entitled to use the same vocabulary as other workers in the same field when addressing himself to a scientific society, but unfortunately insufficient care is often taken

in regard to the introduction of new terms even here. Moreover, many scientific workers are guilty of confused thinking and want of care in arranging their ideas in logical sequence or in expressing them concisely."

"Such careless writing places difficulties in the way of the appraisement or evaluation of the work of the scientific investigator by his own colleagues and still more in its interpretation to the non-technical man or general public. The scientific worker has to remember that his work has not fully achieved its purpose until it is understood and can be integrated into the general body of knowledge of the science or industry."

"This in turn demands from the scientific worker not only a much greater respect for accurate and lucid writing, and more whole-hearted attempts to see that the careless use of words does not invalidate accurate and painstaking experimental work but also an appreciation of the position and work of the expositor, and in particular of the work which the Press is trying to do. High ability in research and felicity of exposition are by no means always linked in the same person, and investigator and expositor have each their place to fill and merit their own reward. The lack of regard of scientific men for some of the ablest expositors in their own ranks is probably one reason why science is not so widely and well served in that respect as is desirable."

"If most scientific workers have little desire or capacity to transform the special vocabularies of their subjects into the simpler and not necessarily sensational forms required by the general reader, remembering these things, they should be more grateful for the service rendered to science itself by those who are able to present a scientific subject accurately and attractively in a literary style."

"Fundamentally, therefore, this question of publication turns on education, both that of the man of science in the capacity to express himself in terse and lucid English, and that of the general member of the public, whether of the Press or not, so that he has a general scientific background against which to set scientific or technical progress as it is made known. Both aspects are of importance, but it would be a mistake to imagine that the printed word is the only means by which the results of scientific work can be brought before the community."

From an article by D. R. Lewis entitled "Integrating research and extension in agronomy," published in the Journal of the American Society of Agronomy, Vol. 30 (1938), p. 179:—

"The transmitter of science—specifically, the extension agronomist—must realize the probability that action will be taken upon recommendations he makes. It was only a few years ago when he often wondered if anyone would accept those recommendations—now, he must constantly think of the results of large groups accepting them.....we must give more thought to the integrating of research and extension.".....
 "If we grant that there should be more "integrating" of research and extension of agronomy, we may logically inquire, "Why don't we have more of it?" and "What situations tend to hinder integration?" May I catalogue a few of these situations? My list concerns mostly the human elements. Many of the hindrances are due to mutual lack of knowledge and appreciation on the part of research and extension workers."

"We often note the reluctance of certain research workers to assume interest or accept responsibility beyond the scientific discovery. The process of discovery seems to give far more satisfaction than the attainment of use.

The attitude which says, "I've found it! That's enough for me!" reminds one of the college student returning from a date late at night only to be questioned by his room-mate: "Come, tell me about it?" "Well, I called for her in a taxi, took her to dinner, and then to a dance, and home again in a taxi." "Did you kiss her goodnight," pried the room-mate. "Why, no," said the future scientist, "I had done enough for her for one evening."

"While modesty may result in reluctance to assume responsibilities beyond the discoveries, both research and extension would be strengthened if more energy were applied to interpreting the scientific findings to the extension workers. Some of this modesty of the researcher in his relations with the extension agronomists may at times be due to lack of knowledge and appreciation of extension as a method of teaching and a means of getting research results before those who may use them. Some research agronomists of high ability isolate themselves too much. This isolation sometimes leads to inaccurate determinations of the nature of specific soil or crop problems and to the neglect of relationships with other problems.".....

"Both research and extension workers should have a greater awareness of what the scientific method in action really involves. Our thoughts along this line were greatly stimulated a few years ago by a careful exposition of the elements involved in the "engineering approach." At the conclusion of the exposition someone ventured to inquire of the engineer leading the discussion, "Is not the "engineering approach" you describe the same in procedure and spirit as what is commonly termed the scientific method—analysis, formation of hypotheses, and testing?" Our engineering friend replied, "One more element must be added to the scientific method for it to become the engineering approach—there must be action. The engineer does something about it." And without quibbling over terms, we in agronomy may well be more active in integrating research and extension."

"Both research and extension workers in their enthusiasm for their own findings and projects often neglect to correlate their activities and the applications of their findings and teachings with others in the same or related fields. Consequently, our work is often needlessly duplicated or at least not properly integrated into a usable and balanced system.".....

"The very nature of their respective public services often results in extension over-shadowing research, but the remedy for this lies in the complete recognition of the fundamental relationships between the two fields. Planned integration of research and extension in agronomy will bring to the public greater awareness of the basic source of extension teachings and materials—research.".....

"The extension agronomists, aided by a series of lantern slides provided by the investigators, conducted further discussion groups with farmers. From each of these meetings came suggestions as to investigations or methods of research and extension approach to the problems. Naturally, both research and extension approaches were modified by these interchanges.".....

"It is evident to those of us who have participated in this reversible action type of integration that research and extension have profited both as to fundamental knowledge and as to methods of organization and presentation."

From an article by G. de V. Davis entitled "Agriculture and a National Policy" in the Journal of the Australian Institute of Agricultural Science, Vol. 4 (1938), p. 8:—

"Whilst there is no need to endeavour to place extension and research in any order of relative importance, it must be admitted that the field man

works under greater disadvantages. It is he who has to bear the literal heat, and often the literal burden of the outback day.".....

"Yet it is this man who has to translate into practical results of individual and national value the findings of his research colleagues to overcome the reluctance of the farmer—and the Australian farmer has no monopoly of this—to depart from his customary practices, and to break down the suspicions whilst retaining the goodwill of men who may be honestly unable to assess the merits of the revolutionary programme placed before them. Clearly, then, the extension man must be exceptional, possessing an equipment not necessarily better than that of the research man but clearly different therefrom. There are instances of men potentially brilliant on one side of the work who are employed on the other. This of course is not a matter needing any change of policy, but it is mentioned since there are awful examples of it to be found here and there throughout the Commonwealth. Field men, too, must be not permitted, but as a matter of policy expected to travel abroad so as to observe in other and older countries the reactions of farmers to expert advice, as well as, of course, details of practice."

"Another need is for the establishment of a fixed departmental policy on all matters open to question. It would surprise you as much as it surprised me to learn in how many instances individual belief is permitted to overrule actual departmental findings, let alone generally accepted tradition. Since human beings are fallible and mortal, the dangers of this will be obvious."

Advisory Work: Estates

As already stated, the Botanical, Chemical and Soils Divisions were below strength for the greater part of the year, so that advisory work to estates was still liable to be less prompt than it should be. None the less, the majority of enquiries were answered without undue delay; with the staff at full strength in 1938 it is expected that a completely prompt service will be possible, provided it is remembered that some enquiries necessarily take some time to deal with adequately.

The following table includes a summary of the advisory work of Divisions in 1937 in connection with enquiries from estates, though also included in these figures are visits, correspondence, and interviews relating to experiments on estates. The figures in brackets are the corresponding data for 1936.

The tours shown in the bottom row of the above table were distributed among States and Settlements as follows:— Johore, 13; Negri Sembilan and Malacca, 11; Selangor and Pahang, 6; Perak, 14; Province Wellesley and Kedah, 10; Kelantan, 2; and one tour (by air) of all rubber areas west of the main range, for Oidium survey. Included in this distribution are four tours by the Director (Kelantan, Kedah, Negri Sembilan—Malacca, and Johore), which are not shown in the table. I also made about 25 individual estate visits, and gave two lectures, not shown above.

On the whole these figures show a moderate increase in the volume of such work, compared with 1936. The volume of

correspondence for the four Divisions taken together shows a slight advance; Botanical and Soils Divisions are not very different from 1936, Chemical Division shows a decrease and Pathological Division a marked increase. In addition to the letters dealt with in Divisions, over 3,000 letters were received and dealt with in the offices of the Director and the Secretary. Interviews show increases for all Divisions, and especially for Chemical Division. Examination and analysis of samples and specimens shows a slight

	Division				
	Botanical	Chemical	Pathological	Soils	Total
Visits to estates (excluding Experiment Station)	178	121	83	262	644*
Interviews at the Institute ...	174 (164)	349 (221)	91 (79)	145 (110)	759 (574)
Lectures ...	4 (2)	3 (2)	1 (1)	7 (10)	15 (15)
Letters received ...	1737 (1831)	927 (1158)	1508 (840)	1330 (1375)	5502 (5204)
Letters sent ...	1949 (1805)	1162 (1406)	1435 (1053)	1763 (1617)	6309 (5881)
Specimens and samples received for examination and/or analysis ...	137 (233)	595 (658)	764 (850)	1090 (850)	2586 (2447)
Tours of visits ...	11 (11)	14 (10)	5 (6)	23 (20)	53 (47)

* The 1936 figures for visits, as given in the report for that year, are erroneous and are not shown here; by an oversight a number of visits to the Experiment Station were included in the figures for that year.

increase. Although the number of estate visits is somewhat less than in 1936, the number of tours of such visits has increased. The total car-mileage involved in twelve months' visits by the staff of Divisions was 5682* miles, or an average of 421 miles per month per Research Officer, to which must be added a certain amount of rail-travel. The visits to estates correspond to an average of one per week per Research Officer, and the interviews to one every five days per Research Officer. It will be realised that actually the distribution of this work among the officers of a Division is very uneven: one officer may have several times the above averages and another only a fraction thereof.

The relative incidence of requests for advice on different subjects is shown in the analyses of correspondence by Divisions which form an Appendix to this report, and these subjects are also dealt with in the reports of the Divisions.

Smoked sheet, smoke-houses and latex-preservation were the chief items of enquiry to the Chemical Division. For the Botanical Division, choice of planting material and methods of tapping were the principal subjects of enquiry, whilst for the Soils Division the majority of enquiries related to manuring, replanting, and leguminous covers. Enquiries and visits in connection with experimental planting of reserve areas bulked large in the work of both the Botanical and Soils Divisions, though this work relates primarily to research rather than advisory work. For the Pathological Division the greatest number of enquiries related to root-diseases, particularly in connection with replanting; to leaf disease; and to various insect pests, notably cockchafers.

The Small-Holders' Advisory Service

As from his appointment as my personal assistant in May, Mr. Moore was made responsible to me for the supervision of this Service; most of the following is based on his annual report to me thereon.

STAFF

At the beginning of the year there were 19 Asiatic Rubber Instructors. In May 1937 five new men were recruited, from the School of Agriculture, Malaya, bringing the Service up to its full strength of 24 according to its (then) cadre. These men were given the usual periods of specialised training at Serdang, at the Institute, at the Experiment Station, and in the field with older A.R.Is., and by the 1st September had all taken up stations of

** This figure is for the 12 months April 1937 to March 1938.*

their own. At the end of 1937 the 24 A.R.Is. were distributed as shown in the following table:—

Distribution of Asiatic Rubber Instructors on 31st December, 1937

Stationed in	Malays	Chinese	Indians	Total
Perak	2	1	—	3
Selangor	2	1	—	3
Negri Sembilan	1	—	1	2
Pahang	2	—	—	2
Johore & Singapore ...	2	2	—	4
Kedah	2	—	—	2
Kelantan	1	—	—	1
Malacca	1	1	—	2
Penang & P.W.	1	1	—	2
Brunei	1	—	—	1
R.R.I. Expt. Station ...	1	—	—	1
On leave	—	—	1	1
Total	16	6	2	24

A Malay Rubber Instructor has been promised for Trengganu. The man selected, who is one of our most experienced A.R.Is., had three or four months' special training at the Experiment Station at the end of 1937, and arrangements were made for him to go to Trengganu early in 1938.

EXPANSION OF SERVICE

When the Service was inaugurated in 1934, it was intended that the number of Asiatic Rubber Instructors should be 22. In 1936 the appointments of an A.R.I. for Brunei and of one for the Experiment Station were approved, thus bringing the cadre up to 24. It has now been decided to have more A.R.Is., for the following reasons:—

A small-holding is a holding of less than 100 acres. There are in Malaya some 1,215,000 acres of small-holdings, forming

nearly 37 per cent of the total area planted with rubber trees. These small-holdings produced in one year (1936) some 132,000 tons of rubber, which was over 36 per cent of the total rubber produced in the country. Small-holders contribute to the support of the Institute on the same basis as all other Malayan rubber producers, *i.e.*, in proportion to the amount of rubber they produce. This means that they provide about 36 per cent of the income of the Institute and are therefore entitled to a corresponding measure of help and advice.

Some of the results of the Institute's work reach the small-holders indirectly, but the only direct and efficient way is through the Asiatic Rubber Instructors. With only 24 A.R.Is., each one has to serve a nominal average of 50,000 acres of small-holdings. Since the Chinese and Indian A.R.Is also help many smaller Asiatic estates which are not counted as small-holdings, the effective average is probably over 60,000 acres per A.R.I. At any given time and station an A.R.I. may cover roughly 10,000 acres, estimated to correspond to at least 3,000 individual owners, so that the country is at present being served at any one time to the extent of about one-sixth.

In view of the foregoing, the Board of the Institute at its meeting in November 1937 decided to recruit more Asiatic Rubber Instructors. Malays are needed most. Good recruits should be obtainable from the School of Agriculture, Malaya, at the rate of four or five per year, so that if recruiting is continued the service will be doubled in about six years. By then, having regard to the movements of A.R.Is. which will have taken place meanwhile, the small-holders throughout the country should be well served unless unforeseen problems arise.

ASIATIC RUBBER DEMONSTRATORS

One A.R.I., supported by the State Agricultural Officer under whom he worked, made the suggestion that a demonstrator be appointed to help him with routine demonstrations. For example, in working through a group of holdings, the A.R.I. could give the first lectures and demonstrations, and then leave the demonstrator behind to continue daily demonstrations whilst he himself organised other work elsewhere. In this way the ground could be covered more quickly, and at the same time the lessons would receive an emphasis without which they are often forgotten. The demonstrator must be a local man, with an intimate knowledge of local conditions. Otherwise no special qualifications are needed.

The Board approved of the idea being tried, and the first Asiatic Rubber Demonstrator was appointed to start work in Kelantan on January 1st, 1938. His salary is approximately only

one-quarter that of the A.R.I. under whom he works, and yet with his help the scope and effectiveness of the A.R.I. may be doubled, especially in a backward district.

SUPERVISION AND ORGANISATION

For the purpose of routine supervision and discipline, each Asiatic Rubber Instructor is attached to the Agricultural Officer of the District, State or Settlement in which he works. The help thus given by the Department of Agriculture and its officers is most valuable. Without it an efficient Small-Holders' Advisory Service could not be carried on unless there were a far more elaborate organisation at the Institute.

Technical advice is given direct from the Institute to A.R.Is, who are supposed to write for advice whenever they need it. Actually, by visiting them in the field, it has been found that many A.R.Is are reluctant to refer their problems to head-quarters. They hesitate to trouble officers of the Institute with what might appear to be small matters; or they do not wish to show their ignorance even when quite excusable; or they may be faced with a problem and not know it. There is therefore a need for better *personal* contact between the Institute and its A.R.Is. This can only be achieved satisfactorily by an officer of the Institute visiting each A.R.I. in the field every three or four months, observing his method of working and the results obtained, and giving there and then any advice that is needed.

During the latter half of 1937 I arranged that Mr. Moore should spend about a week each month in visiting A.R.Is. In this way each A.R.I. (excepting in Brunei) was visited for one or two days. These visits proved very useful. Some mistakes were rectified, a few new problems were discovered, and the A.R.Is appreciated the increased interest being taken in their work. It is clear, however, that yearly or half-yearly visits of a day or so to each A.R.I. are not enough, and as the number of A.R.Is increases, even these would be difficult to arrange with the present staff. The Board therefore approved the appointment of a full-time European officer for the Small-Holders' Advisory Service. The appointment is intended to be filled before the next batch of A.R.Is. is recruited in May 1938.*

A.R.I. AT EXPERIMENT STATION

Towards the end of 1936 the Board agreed to having always one A.R.I. at the Experiment Station. The first one appointed went there at the end of April 1937 and stayed until the middle

* Mr. R. H. Meikle, B.Sc., was appointed in March and took up his duties as Small-Holders Advisory Officer in May 1938.

of November. The second arrived at the beginning of November, and was still there at the end of the year. The intention is that each man chosen shall stay there about six months. During this period he receives a thorough practical training which increases his efficiency as an adviser of small-holders, and, at the same time, he is useful in the ordinary work of the Station and for showing round Asiatic visitors. He can also do small outside jobs in connection with small-holdings, for which no regular man can be spared, and can assist any A.R.I. in any special work.

The experiment so far has been a success. The A.R.I. already trained, and the one now in training, have obviously benefited. It is hoped that A.R.Is will look upon the appointment to the Experiment Station as a distinction to be coveted and earned. They cannot all have it and yet, as the A.R.Is become due for promotion, it will be in a man's favour if he has spent a few months at the Experiment Station.

ADVISORY POLICY

The function of the Small-Holders' Advisory Service is to give advice to all small-holders on all technical aspects of rubber-production. It is, however, no use giving a small-holder advice which he cannot or will not follow. Therefore the general policy so far has been to concentrate on advice that is cheap and easy to carry out, that does not conflict seriously with the average small-holder's prejudices, and that offers immediate and obvious advantages. It is hoped that in this way the A.R.Is will win the confidence of the small-holders, so that the latter will eventually be willing to take heed of advice which calls for the expenditure of time, money, and labour.

One important obstacle to advisory work is the "absentee owner." When the owner of a holding lives elsewhere it is almost impossible to get anything done, as the people left in charge have little or no interest in its welfare or have no authority to undertake improvements. This difficulty is worst on Indian holdings, where the owners are often Chettians who rarely have any interest in plantation matters. On Chinese holdings the difficulty is not so great. Although Chinese owners frequently live away from their holdings they are usually closely interested in them and if they can be approached will listen to advice. On Malay holdings there is generally little difficulty in approaching the owners, but it often happens that nothing can be done because the holding is mortgaged or is leased to some other person. Greatest progress is therefore made on holdings on which the owners live and work themselves. A.R.Is keep this fact in mind and direct their efforts accordingly.

PREPARATION OF RUBBER

The first and most obvious way of helping the small-holder is to teach him how to improve the quality of the rubber he produces. To do this he need spend little or no money, but must learn to exercise unaccustomed care and cleanliness. Teaching the correct method of preparing good sheet rubber is the easiest, the most profitable, and the most needed line of propaganda at present. It has been the principal work of the A.R.Is since the service started in 1934, and is likely to remain so for some years.

In connection with this work the small-holders' smoke-cabinet, introduced in 1935, continues to be of prime importance, especially in the more remote districts where the price received for smoked sheet is often much higher than for unsmoked. The outstanding example is Brunei, where at one time it was reported that smoked sheet sold for \$10 per pikul more than unsmoked. As a result, nearly 200 small-holders' smoke-cabinets were built during 1937, within a year of an A.R.I. being sent there. This means an average of one smoke-cabinet to every 38 acres of small-holdings. Since each cabinet will serve about 15 acres of rubber, Brunei is now nearly half-way towards "saturation point." Similar results are hoped for in Trengganu in 1938.

It is gratifying to record steady progress in improving the quality of rubber produced by small-holders, with consequent profit both to them and to the country as a whole. The total result is, however, still small compared with what is possible. This is partly because the Advisory Service is still very young and only a small proportion of the small-holders have yet been reached; and partly because of difficulties in the way of marketing, for which some kind of grading scheme appears to be the solution.

MARKETING : PRICE-GRADING SCHEME

In some districts the small-holders do not feel encouraged to produce good smoked sheet because they do not get paid enough extra for it. Some rubber-dealers possess smoke-houses of their own, and prefer to buy wet sheet at a low price and smoke it themselves. Such dealers are not likely to offer a fair price for sheet smoked by the small-holder. In other cases dealers say that they would pay more for good smoked sheet if there were enough of it, but until there is what they consider enough they will not pay any more. This creates a vicious circle into which it is difficult to break. Furthermore, small-holders are frequently indebted to their rubber-dealers, which makes the position still worse.

An attempt to improve matters was made in Pahang at the end of 1935, where the licensing authorities agreed to introduce a Price-Grading Scheme suggested by an A.R.I. The essence of

this scheme is that every rubber-dealer, as a condition of his licence, is obliged to exhibit a board showing:—

- (a) the date,
- (b) the Singapore Standard Price,
- (c) samples of various grades of rubber, and
- (d) local prices offered for those grades.

In this way the small-holder who brings rubber to sell can see at once how much he should be paid for it. The price differences between the grades are adjusted so that the producer of low quality unsmoked rubber is penalised and the producer of good smoked sheet is rewarded.

The Pahang Price-Grading Scheme has now been working two years and can be considered a success. The amount of unsmoked sheet produced has greatly diminished. There has not yet been as much improvement in the quality of smoked sheet as was expected, but the fact that small-holders smoke their sheet at all represents an important advance.

The possibility of introducing similar Price-Grading Schemes in other parts of the country is now being considered, and the active assistance of the authorities concerned will be sought. The question is a national one. At present there is still a great deal of rubber produced on small-holdings, which is so dirty that it must be remilled before being exported. Even the better quality small-holding rubber is usually not good enough to command the full price abroad. The money which small-holders lose by producing inferior rubber is mostly a dead loss, for very little of it is gained by anyone else. This loss can be avoided, for it is well known, from the entries at rubber competitions and from other observations, that small-holders can produce excellent smoked sheet if they wish. The problems of persuading them to do so, and of seeing that they are not unfairly exploited in so doing, are of national importance, for as little as one cent per pound extra on say 100,000 tons of rubber per year means that over two million dollars more would come into the country annually.

TAPPING

Another direction in which much improvement is needed on small-holdings is tapping. The commonest tapping system seems to be a one-third-circumference cut tapped daily. Bark consumption is often about three inches per month, and wounding is of general occurrence. To halve the bark consumption and to cease wounding cost nothing but care, but it is very difficult to get the small-holder to give care to these matters. There is no *immediate* advantage in improving tapping, and the average small-holder is

unmoved by warnings as to what will happen a few years hence if he goes on wasting his bark and wounding his trees. More intensive propaganda is needed in this direction, and has been started.

PESTS AND DISEASES

The most serious disease affecting small-holdings is Mouldy Rot, for which treatment is required by law. During the slump of 1930-34 the law could not easily be enforced, and the disease caused much permanent damage. In more recent years, with the improved price of rubber, there has been much less evasion. Considerable improvement took place in 1937, helped by the Agricultural Department's policy of selling approved fungicides in quantities small enough for the small-holder to buy.

The termite pest "White Ants" is now being treated on many of the younger small-holdings. Root-diseases are being dealt with on approved lines on a few holdings in various parts of the country, but in general they are neglected. Fortunately, because the land was usually previously cultivated for other crops, root-diseases are not such a serious problem on small-holdings as they are on large estates.

TREATMENT OF LAND AND SOIL

Propaganda in favour of growing desirable natural covers has continued with fair success. There was some difficulty at first because small-holders feared that if they allowed jungle plants to grow they would be given fewer "coupons," *i.e.* the productive capacity of their holdings would be assessed at a lower rate. This difficulty is now largely disposed of, and many holdings can be seen developing a good cover of desirable plants.

Other methods of conserving and improving the land and soil, such as terracing, bunding, and drainage, are practised only in a few isolated cases. No manuring has yet been recorded on small-holdings, and only a little on the smaller Asiatic estates, but interest in this subject appears to be awakening. The same remarks apply to replanting also.

BUDGRAFTING

Budgrafting has been done on some half-dozen holdings, where there were trees, planted just before Rubber Restriction was introduced in 1934, which had not yet grown too big for budding. The Institute helped the owners to obtain the necessary materials and to carry out the work.

The Department of Agriculture, Johore, decided to establish a budwood-multiplication nursery at Tangkak Agricultural Station

to supply budwood to neighbouring small-holders who might need it in the near future. Budding was done in November 1937, by an A.R.I. and a Chinese budgrafter sent from the R.R.I. Experiment Station with the necessary materials. A very successful demonstration was given to a gathering of some 200 small-holders.

The A.R.I. from the Experiment Station has also helped with the courses in budgrafting given to the students at the School of Agriculture, Malaya.

SHOWS

During 1937 the Institute supplied exhibits, showing the correct methods of making and smoking sheet-rubber and of treating diseases, to 18 district Shows and Rubber Competitions. The exhibits were in the charge of one or more A.R.Is who gave explanatory talks to visitors. Many of the Shows were also visited by officers of the Institute.

At the Malayan Agri-Horticultural Show held 31st July—2nd August, exhibits of interest to small-holders were provided and A.R.Is were on duty to explain them. The Institute also assumed responsibility for arranging and judging the entries in the All-Malayan Small-Holders' Rubber Competition, which formed part of the M.A.H.A. Show.

CONFERENCES OF A.R.Is.

Conferences were held when the A.R.Is visited Kuala Lumpur for the official opening of the new buildings of the Institute in May, and again following the M.A.H.A. Show in August. The Conference in May lasted two days, consisting of discussions and a visit to the Experiment Station. The Conference in August lasted three days, consisting of discussions, lectures by certain A.R.Is to their fellows, and a special visit to an estate to study root-disease treatment.

PUBLICATION

During 1937 an illustrated elementary manual on rubber-growing was prepared, with the help of all Divisions of the Institute, to be published early in 1938. Although the book has been prepared primarily for small-holders, the English edition will probably prove useful on estates also. It is intended that the manual shall be translated into Malay, Chinese, and Tamil, for distribution to such small-holders as are able to appreciate them and who cannot read the English edition.

RURAL LECTURE CARAVAN

The Caravan, operated jointly by the Department of Agriculture, the Co-operative Societies Department, S.S. & F.M.S., and

the Institute, toured the rural districts in 1937 as in previous years. The appropriate A.R.Is attended the Caravan, giving lectures and demonstrations and providing commentaries to the films and slides dealing with rubber cultivation.

EXPERIMENTAL WORK—AMPANG

In order to carry out experiments—especially on replanting—under conditions peculiar to small-holdings, the Institute acquired 18 acres of small-holding rubber at Ampang. One block of four acres is in Ampang Road directly opposite the Institute. The rest, in two separate blocks, is only one and a half miles away.

Three small areas of roughly one acre each were selected for experimental replanting, and were cleared and planted before the end of November 1937. The shape and disposition of the experimental plots were designed so that the effects of different degrees of shade from the surrounding trees on the growth of the young plants could be studied, as shade is likely to be an important factor in replanting under small-holding conditions. In addition to their purpose as experiments, these plots will be used to demonstrate how small-holders can apply modern planting methods.

The uncleared portions of the holdings are in regular tapping, and provide a small but valuable quantity of absolutely fresh latex for the Chemical Division, the interval between the tree and the laboratory being reduced to a few minutes if required. The Botanical Division also uses the holdings for experiments on bark renewal.

Research and Experimental Work: General

In the report of the Engledow Commission on the Rubber Research Institute of Malaya (1933) it is stated that:—

“We take the purpose of the Institute to be the employment of the sciences for the betterment, in the sense of the economic advancement, of rubber-growing in Malaya;” and:—

“It is commonly agreed that the policy of applied research must be determined by the main economic circumstances, immediate and future, of the industry concerned;” and:—

“The first step in planning the work——of the Institute must be a study of the main features of the economic situation of rubber-growing in Malaya.——From the results of this study there should be made a selection of the major problems of the rubber-producer in Malaya.——The volume of selected problems must be commensurate with the Institute’s staff and other facilities; due weight must be given to the tangibility of the problems; and it is of the highest importance to distinguish between transient problems and those sufficiently enduring to warrant undertaking protracted research.——We hold that the attack should open with a full study of the economic background and the practical aspects of each problem as known to the planter, the merchant and the manufacturer.”

ECONOMIC CONSIDERATIONS

The emphasis placed upon economic considerations in the above statements is evident, and rightly so for an organisation such as this Institute, which exists for the betterment of an Industry.

A study of the following sections of this report, and of the reports of the Divisions will show what work is being done. The programme of work must, however, be passed constantly under review. Problems other than those already covered by the work in progress or planned, are continually calling for consideration, and vie with those already covered by the programme, for inclusion therein.

A limit is fixed to the total amount of work in progress at any time, by the size of the staff, and the facilities at its disposal. A touchstone is therefore required whereby all problems which have been stated, and which merit consideration, may be given an order of precedence. Such a touchstone can be afforded by a detailed costings-analysis of the average costs of rubber-production.

Sufficient data are now available to allow reliable *average* values to be given to the cost of each individual operation or factor involved in rubber-production, from the clearing of the land up to the time that the finished crude product leaves the estate factory for shipping. Up to the stage of the collection of the latex from the cups in the field, these values will be on the "cost per acre" basis, whilst for the subsequent operations, from the collection of the latex in the field to the despatch of the product from the estate factory, the values can be calculated in terms of "cost per lb." This latter category comes wholly within the province of the Chemical Division, while the former comes wholly within the provinces of the other three Divisions.

Sufficiently detailed data for the costings-analysis mentioned above are now available, and it is intended that in the future issues of the programme of work of this Institute, the system of classification of individual items will include an indication, derived from the cost of the relevant factor or operation, of the relative order of economic importance, and therefore of precedence, of the item in question.

There are also certain other problems, eminently practical, and of supreme importance to the industry, the economic importance of which cannot be defined on the "cost per acre" or the "cost per lb." basis. Such problems are primarily those concerned with the development of improved, higher-yielding planting material. The Engledow report, in discussing the work of the Institute, referred to the "maximum yield per acre to ensure

minimum cost per pound" of several of the witnesses examined by the Commission. The economic classification of these problems forms a link between the two other bases mentioned above, for in so far as a profitably increased yield per acre is an important aim for any estate, and in so far as it is compatible with restriction of production from Malaya as a whole, the use of higher-yielding planting material, by increasing the yield per acre, enables a given expenditure per acre to result in a reduced cost per lb. of rubber produced.

Investigations aiming at increasing the yield per acre by manuring or other method of treatment of soil or trees can be classified on a "cost per acre" basis, but work on the development of improved planting material cannot be so classified. This work is of such dominant economic importance to the industry, however, that it must be given a prior position in the order of precedence of the items in the research programme, superior to other items the order of precedence of which depends on considerations of "cost per acre" or "cost per lb."

Whilst the order of precedence of practical problems in the programme of any Division will be determined in large part by economic considerations in the manner suggested above, these cannot always be allowed to operate alone. Problems of obviously great economic importance may sometimes have to be left aside because of their intangibility, but in such a case, intangibility must not be allowed to exclude the problem from the programme without more ado, and efforts must be directed to find means of making the problem tangible. Problems of purely transient interest obviously cannot be allowed to figure largely in the work of the Institute, but since they will usually also be problems of comparatively minor economic importance, this factor alone will serve to place them fairly low in the order of precedence.

Thus, whilst economic research is outside the scope of the work of the Institute, it by no means follows that economic considerations must therefore be entirely neglected. It is, indeed, of the utmost importance that available data on the economics of rubber-production, and on the costing of the various operations and factors involved, should be closely studied and should form the basis for determining the orientation of much of the Institute's work and for deciding the order of precedence of the items in its programme. Moreover, Research Officers must familiarise themselves with such economic and costings data, which must form part of the background of their research work.

FUNDAMENTAL WORK

The above considerations apply chiefly to utilitarian problems, with obvious direct practical application in the industry. The

importance of work on fundamental problems relative to that on more immediate practical problems, cannot be assessed in the same way, but fortunately in practice this is not necessary, since decisions regarding the relative amounts of work on the fundamental problems and on the more immediate practical problems can usually be taken on other fairly clear-cut issues. The same is true regarding the choice between different fundamental problems in the programme of any one Division.

There is a fundamental basis of knowledge of and problems in pure science, which underlies the practice and the practical problems of rubber-production; and it is an essential feature of the programme of the Institute that work on such fundamental problems of pure science shall be undertaken (a) whenever it is needed to provide scientific knowledge without which a related and approved practical problem cannot be adequately investigated; and (b) when such fundamental work offers reasonable possibility of providing new knowledge of a kind which can be utilised in new practical applications of potential economic benefit to rubber-producers. Work of the latter type is often termed "long-range" work, but this is a term which I prefer to avoid, because critics of so called long-range work often speak of it as if the target, because it is invisible, is also vague, or even non-existent. This should not be true of the kind of fundamental work that I have in mind in my reference under (b) above. The *kind* of target should be in mind, even if its vulnerability, its distance, and its size are uncertain. For example, work on the chemical nature of the constituents of latex is fundamental work, one of the conceivable outcomes of which (or the target, if one prefers to call it long-range work) might well be to show how the natural rubber-substance could be modified to make it better than synthetic products in respects in which it may at present be surpassed by the latter.

SCOPE OF WORK OF THE DIVISIONS

Before dealing with the work of the Divisions individually it is desirable to outline the whole field of work of the Institute and the manner in which that field is divided amongst the four Divisions.

The field in question may be defined as embracing all technical problems of rubber-production in Malaya up to the time of the export of the product from the country together with some problems of consumption-research (see below). It has been stated above that although due regard to the economic background is a cardinal feature of the Institute's programme of research, economic research is not normally within its scope; the above reference to

technical problems thus excludes purely economic ones, but it includes all problems for the statement or elucidation of which the natural sciences (including mathematics) can be applied.

The broad lines of the allocation of this field among the Divisions are as follows, taking the Divisions in a logical order based on the natural sequence of events and operations involved in the production and export of Hevea rubber:—

Soils Division

All problems relating to the preparation of land for planting, and to the treatment and maintenance of the soil thereafter. Ecological problems.

Botanical Division

All problems relating to the growth and treatment of the Hevea plant itself in health, throughout its whole life from seed to old age. Ecological problems.

Pathological Division

All problems relating to the diseases and pests of the Hevea plant and of other plants grown in association with it. Other microbiological problems relating to such plants, to rubber soils and to latex and raw rubber.

Chemical Division

All problems relating to latex, from the time it leaves the tree, and to the raw rubber made from it, up to the time of export from Malaya.

The above allocation is of course not absolutely clear-cut, and there are many problems of concern to more than one Division. In most cases such problems are still primarily the concern of one Division, with other Divisions participating only in a subsidiary, though none the less essential, capacity. In certain cases, however, there are problems of roughly equal interest to two Divisions, in which case joint work and the closest co-operation are needed. This is true notably for the Soils and Botanical Divisions, the work of which must necessarily be closely inter-locked. The rubber tree and the soil in which it grows are one system, and many problems of rubber-growing concern that system as a whole. Thus problems of manuring rubber soils are closely linked with those of the nutrition and metabolism of the rubber tree. Again, the ecological problems arising from the use of cover plants, "natural" and otherwise, concerning as they do the growth of these plants and their interaction with one another, with the rubber tree, and with the soil, are essentially problems

of joint interest to and for common action by these two Divisions, so that in the above dichotomy they have been shown against each Division.

The *Statistics Section* of the Institute was in process of being organised at the end of the year, following the arrival of the Statistician in November. This Section gives advice on the design and layout of experiments, and conducts or supervises the analysis of their results. This work involves close collaboration with all Divisions, but particularly with the Botanical and the Soils Divisions. An important aspect of its work which specially concerns both of those Divisions is the study of the technique of recording yields of individual trees, and of sampling methods for the estimation of plot yields in field experiments, whereby greater reliability of results is to be attained. Furthermore, the Statistics Section will study and analyse the great amount of accumulated data relating to seasonal variations in yield, the influence of climatic and soil conditions on yield, and the rate of growth and of increase of yield with age.

CO-OPERATION WITH OTHER COGNATE RESEARCH ORGANISATIONS has continued during the year under review, in varying degrees. Close collaboration with the scientific staff of the London Advisory Committee for Rubber Research (Ceylon and Malaya) is a standard feature of the work of the Chemical Division, and is referred to further in the report of that Division and in the Technical Appendix to the report of the L.A.C. which is also published herewith. The newly-constituted British Rubber Producers' Research Association is referred to in my notes on the work of the Chemical Division which follow later in this report. It was fortunate that the newly-appointed Director of that Association, Mr. J. Wilson, was able to visit the East towards the end of 1937, thus establishing personal relations between his Association and this Institute.

Frequent correspondence has been exchanged on matters and problems of mutual interest, with the Rubber Research Scheme, Ceylon; the Proefstation West-Java, Buitenzorg; the Proefstation Mid-Java, Malang; the Besoeki Proefstation, East-Java; the A.V.R.O.S. Proefstation, Medan, Sumatra (East Coast); as well as with various private research organisations such as the H.A.P.M. Research Department, and the Goodyear Research Department in Sumatra.

In Malaya close touch has been maintained, and in many cases collaboration has occurred in experimental work, with the research organisations of planting groups such as Dunlop Plantations Ltd., Socfin Co. Ltd., Guthrie & Co. Ltd., Harrisons, Barker & Co., Ltd., and with the B. F. Goodrich Research Station in Kuala Lumpur.

Personal contact with the rubber research organisations in Ceylon and the N.E.I. has unfortunately been scanty during the year. Mr. Piddlesden, of the Chemical Division, visited the West Java Proefstation during local leave in Java; and visits to this Institute were made by Mr. C. C. Ament, Adviser of the Algemeen Landbouw Syndicaat and of the Centrale Proefstations Vereeniging, Batavia, Java; Messrs. C. Barclay, J. F. H. Cronshey, W. E. Cake, J. Grantham, M. D. Knapp, E. M. McCole, of the H.A.P.M., Sumatra; Mr. W. N. Bangham of Goodyear Rubber Plantations Co., Sumatra.

There is a real need, and much scope, for closer cooperation and collaboration among all the official research organisations of rubber-producers in the different countries in the East. Official international collaboration of the newly-formed research organisations for work on "new uses," in Europe, is already an accomplished fact, and it is much to be desired that something of the same sort may be achieved in the near future with regard to production-research in the East. A large part of the research and experimental work in each country must be carried out there, since the effect of local conditions of soil, climate, etc. must be taken into account; though even for these, cooperative work may result in some economy of effort. There remain, however, many problems, not all fundamental, regarding which considerable duplication and over-lapping may occur, and could be avoided if a joint programme were agreed upon.

Experimental Planting

Under the current International Rubber Regulation Agreement, new planting of Hevea on reserve lands is permitted, for experimental purposes, to the extent of one-quarter of one per cent of the existing planted acreage. For Malaya the permitted area is thus 8,177 acres. Owing to the delayed publication of the Annual Report for 1936, it was possible to include therein a statement (p. 38) showing the allocation of experiments at 31st July, 1937. This showed a total area allocated to experiments, of 7,666 acres, leaving 511 acres still to be allocated. Most of this balance remained unallocated at the end of 1937; not only would allocation later than July have been too late to make successful clearing and planting practicable before the end of the year; but also, it was decided to reserve this small balance until, early in 1938, a final choice could be made of the further experiments required, to be planted in that year.

The area actually planted by 31st December, 1937, was 5,428 acres; the balance of slightly over 2,000 acres allocated but not planted, represents approved experiments the planting of which, for various reasons, had to be postponed until 1938.

The existing Agreement expires at the end of 1938, and all experimental planting thereunder must then cease. A final summary and analysis of the experiments under the scheme will therefore be held over until the report for 1938. The reports of the Botanical and Soils Divisions herewith, however, contain frequent references to and information regarding these experiments.

Soil Problems

THE PRIME OBJECT OF THE WORK OF THE SOILS DIVISION is to study Malayan soils in relation to their suitability for growing high-yielding rubber trees, with a view to advising on the suitability of individual soils, and on the methods of treatment best calculated to give the most profitable results.

Soils vary greatly in their properties and in their suitability. The study of Malayan rubber-soils, in common with that of the soils of any country, involves three separate but closely linked phases of investigation: soil survey, laboratory examination, field experiments. Although confident and fully reliable advice on practical soil problems cannot be given until all three of these phases of investigation have been reasonably fully developed, the relative amount of attention that they must receive at a given time must take account of the time required to develop each phase.

FIELD EXPERIMENTS require most time, not only because their results are subject to influence from variations in weather from year to year, so that they must be continued long enough for such variations to be studied and to average out; but also because, in the case of Hevea, five or six years must elapse between planting and coming into bearing, and several years more before maturity. Since the final judgment of the results must depend on yields at maturity, most field experiments with Hevea have to continue for several years—perhaps only five or six for experiments which start on mature or even post-mature rubber, up to ten or twelve years, or more, for experiments which start from the time of planting.

The results of field experiments must be considered in relation to the type of soil on which they are carried out. Since field experiments are so costly and time-consuming, it is important that they should be carried out simultaneously on all the different kinds of soil of importance; and that on any one kind of soil they should be carried out only in such numbers as are necessary to ensure sufficient reliability in the results obtained.

These requirements can be fulfilled only when the results of a *soil survey* are available. A preliminary soil survey must be made first, before the experiments are laid down, so as to define the main soil types and to delimit approximately the areas in

which they occur. After the experiments have been laid down, and during the necessarily long period during which their results are accruing, the soil survey can then be developed in more detail, to define the variations in properties of the soils in each main type, and to delimit the boundaries of the areas of the main types and of the sub-types within each.

Such a soil survey will be based primarily on a study of the *soil profile*, in relation to local conditions of geology, topography, climate and so on. The ultimate aim of this phase is the preparation of a *soil map* showing, for all rubber-lands, the kinds of soil which occur, in terms of the main types and the sub-types within each.

Both of the phases of work discussed above consist of field work, and to complete the scheme the third phase of *laboratory investigation, including soil analysis* is required. It is necessary to define the differences between soil types, and the variations within them, in terms of chemical and physical composition (in relation to the profile), so that the results of the field experiments may be properly used as the basis for advice on the practical soil problems of other areas.

It is obviously impossible to carry out an experiment on every field or estate for which advice on soil problems is needed—or if not impossible, the amount of time required to get an answer is so long as to make it impracticable, and to be avoided if a reasonably reliable answer can be got quickly by other means. The existence of profile, chemical, and physical data, for the main soil types and sub-types within them, provides that means.

When an enquiry relating to a soil problem on a given estate is received, reference to the soil map will show to which main soil type and sub-type the area belongs, and the results obtained in field experiments on *similar soil* elsewhere can be consulted. An analysis of a sample of the soil from the area for which advice is sought, may be needed to indicate how it compares with the soil of the areas with the same kind of soil, on which experiments have been carried out. Combined with information on local conditions regarding trees, covers, topography, climate etc., one then has all the necessary data on which to give reasonably confident advice for the estate in question.

The Soils Division has in the year under review, as hitherto, quite rightly concentrated more particularly upon the field-work in the above three phases of its work, and especially on the conduct of field experiments. This phase of the work takes so much longer than the others to reach fruition that all efforts must be made to get it thoroughly established on a sufficiently comprehensive basis first. Whilst awaiting the amassing of a sufficient body of data from this comprehensive scheme of field experiments, more

of the work of the Division can then be devoted to the other phases of the work. The past vicissitudes in the staffing and the organisation of the Institute have weighed particularly heavily on the Soils Division. Only in 1937 did its staff reach a size commensurate with its duties. Moreover, it was not until 1936 that the opportunities afforded by the scheme of experimental planting under the International Rubber Regulation Agreement were made use of to establish a comprehensive scheme of field experiments embracing all soil types of importance. In 1938 that scheme of experiments will become fully established.

Systematic soil survey work was commenced in 1935 when Mr. Hamilton's accession to the staff of the Division made this possible. Considerable progress had been made when the records of this work were destroyed by the fire in September, 1936, but sufficient knowledge of the soil types and their distribution remained to enable the field experiments to be laid down in proper relation thereto. Now that the heavy work involved in the establishment of those experiments is nearing completion, more time can be devoted to catching up the arrears of systematic study of soil profiles arising from the destruction of records in the fire, and to the further development of the survey work.

Much of the laboratory work consists of routine examination of soil samples as part of the soil survey, and for advisory purposes. This work, in common with the field side of the survey work, has had to take second place to experimental work in the field, for the reasons discussed above, and has been similarly delayed by the destruction of laboratories and records in the fire. Here again, the position will be much improved in 1938, and probably more so than for the field side of soil survey work, because most of this routine laboratory work is done by the Junior staff, which has been enlarged, including the temporary engagement of extra men to catch up arrears of analytical work resulting from the fire.

The more specialised side of the laboratory work concerns such questions as the study of the constitution of different types of Malayan soils, involving separation and analysis of clay fractions, studies of the exchange complex, and the like, in relation to differences in physical properties and in fertility; study of the weathering processes giving rise to and occurring in soils; study of soil micro-organisms and of biological processes in soils. Work of this kind has not yet been seriously undertaken, but will be developed in the near future.

Such work, however, as well as much of the soil-survey work, is to supply fundamental knowledge of Malayan soils which is needed not merely by the Institute in connection with rubber-growing, but also by all other scientific organisations or individuals

concerned with the study of the production of other economic crops in Malaya, as well as rubber. Soils work is an important feature of the work of the Department of Agriculture, and of the scientific staff employed by certain planting companies in Malaya. There is much scope for co-operation between all these concerns in their work on these common fundamental problems of Malayan soils, the knowledge obtained being then used by each in its own specialised applied sphere. It is hoped to attain such co-operation by the founding of a Malayan Society of Soil Science, (as a section of the International Society of Soil Science), and thus to effect considerable economy of effort by the co-ordination of work and problems and the pooling of results in regard to these fundamental soil studies.

The report of the Soils Division deals for the greater part with field experiments, for the reasons discussed above. The following explanatory notes refer to the field experiments on estates (exclusive of experimental planting, for a summary of which the report of the Soils (and Botanical) Division should be consulted).

(a) Manuring Experiments

(1) *Old-established experiments.* These have been running for a number of years, properly arranged replicated lay-outs are not in use (except in one instance); the experiments mostly consist of a series of manured and unmanured plots with insufficient or no replication, the comparisons being between various proprietary fertilisers supplying N, P, and K, and fertilisers supplying single plant foods.

Twelve estates are concerned in this class, and various soil types are covered; trees are of varying ages.

(2) *Experiments at Kuala Selangor.* These were started in 1936, on 8 estates. Comparisons between different forms of phosphatic and potash fertilisers, sometimes with nitrogen manures, are being made; the age of the trees is mostly between 20 and 30 years; peat, clay, and peaty clay soils are being utilised; the experiments are all in the form of Latin Squares (4x4 or 5x5). The Institute supplies half the fertilisers; 3 biennial applications are to be made, and the experiments will run for 10 years.

(3) *Experiments on inland soils.* About a dozen estates have well laid-out experiments (Latin Square or Randomised Blocks), making straight comparisons between various types of fertilisers (no "factorial" lay-outs); yields and measurements are taken by the estates and forwarded to the Institute. The trees are from about 10 years old upwards.

(4) (a) *Phosphate manuring experiments.* The same treatments and randomised block lay-out of plots are repeated on 5 estates on different soil types in various parts of the country, the object being to determine the value of phosphates, in addition to nitrogen, in the presence and absence of potash, for mature rubber trees. Two levels of phosphates are used, and a comparison between soluble and rock phosphate is also made.

(4) (b) *Nitrogen manuring experiment.* Different rates and frequencies of application of ammonium sulphate to mature rubber trees are being compared, the trees receiving in addition uniform phosphate and potash manures. One experimental area (in Kedah) has commenced, and two more are to be selected in 1938.

(5) *Miscellaneous manuring experiments.* These cover about 20 to 30 manuring trials being made by estates or which have been suggested to estates by the Institute, and not in special co-operation with us. Records of growth and yield are analysed by us wherever they are available. Satisfactory replication of treatments and plot lay-outs are not always used.

(b) Replanting Experiments

(1) *Experiments solely under direction of estates.* These comprise about 30 to 40 in all, and numbers are steadily increasing.

All varieties of soils and numerous manurial comparisons are included.

(2) *Experiments partly or wholly controlled by the Institute.*

Experiments are in progress on five estates, those on four of these having been started in 1937.

(c) Cultivation and Cover Crop Experiments

(1) *Cultivation experiments in mature rubber.* The number of experiments originally started was seven, but some have lapsed now. Comparisons are being made, of their effects on the soil and the rubber trees, between different types of natural covers and methods of eradication and control, randomised block lay-outs being used. The age of the rubber trees concerned is about 20 years or more.

(2) *Cover crop and cultivation experiments in immature rubber.*

Several experiments have been commenced, some in conjunction with the Botanical Division. The manuring and inoculation of leguminous covers are included in the problems under study.

COLLABORATION OF THE SOILS DIVISION WITH OTHER DIVISIONS occurs primarily with the Botanical Division, notably in connec-

tion with cover-crop problems, with the relation of manuring to the results of different systems of tapping, and with the suitability of different kinds of planting material to different kinds of soil. The last two aspects are dealt with further in the report of the Botanical Division; with regard to cover crops the Soils Division's share of the work concerns studies of the effects of different covers on the soil, with particular reference to erosion and to fertility, and of the effects of the soil on the cover crop with regard to nutrient supply (notably phosphates). Another aspect of the last-mentioned subject is that of the effect of presence of or absence from the soil of the correct strain of nodule-bacteria for different leguminous covers, and the inoculation of the seed with cultures of the correct organism. This work is in close collaboration with the Pathological Division, which carries out the study of the organisms and the preparation of suitable cultures for inoculation, whilst the Soils Division deals with the associated field work.

The ALLOCATION OF WORK AMONGST THE GRADUATE STAFF of the Soils Division is roughly as follows (the figures underneath their names show the percentages of their time devoted respectively to advisory and research work in 1937):—

<i>Mr. C. G. Akhurst</i> (61A:39R)	...	Field experiments, under the Experimental Planting scheme and otherwise. Soil conservation. Cover crop and cultivation problems.
<i>Mr. R. A. Hamilton</i> (34A:66R)	...	Soil Survey. Phosphatic manuring problems. Leguminous cover problems, particularly in connection with nodule-bacteria. Leaf analysis. Laboratory and pot-culture work on soils with particular reference to nitrogen and phosphate studies.
<i>Dr. A. W. J. Dyck</i> (72A:28R)	..	Advisory work, and inspection and supervision of field experiments on estates.
<i>Mr. K. S. Pillai</i> (10A:90R)	...	Supervision of all routine laboratory work, and of some recording work on estates.

No clear-cut line of division between Mr. Akhurst's and Mr. Hamilton's work, or between Mr. Akhurst's and Dr. Dyck's work, is possible; according to circumstance either may deal with work normally looked after by the other, close co-operation being maintained throughout.

A concise and informative review of the research and experimental work of the Soils Division in 1937 is given in its report herewith, under the heading of "Covers," "Replanting," "Manuring," "Experiment Station" and "Experimental Planting," and I shall not further discuss it here.

Botanical Problems

THE WORK OF THE BOTANICAL DIVISION is primarily concerned with the study of the Hevea plant, its improvement, and its treatment; with a view to increasing the yield of latex per acre and reducing the cost of production of raw rubber.

The close inter-relation of the work of this Division and that of the Soils Division has already been mentioned; further reference is made to it below.

THE IMPROVEMENT IN YIELD OF HEVEA by soil treatment, including manuring, though it may be very profitable, is not necessarily so, for the cost of the treatment to the grower may exceed the value of the increased yield. The development of higher-yielding Hevea plants, however, provides the planter with a means of getting increased yields which almost escapes that disadvantage. It is true that the development of high-yielding plants is itself a costly business involving years of work, but that cost falls on the Institute and is thus paid for by the Malayan rubber-growing industry as a whole, from the contribution it makes for the purposes of the Institute; or it falls on certain concerns which specialise in the scientific and commercial development of such improved planting material. The planter's extra costs are confined almost entirely to the extra cost of the planting material itself—and when that consists of budwood he can keep the cost down by propagating it himself for his own use. The subsequent costs of planting and bringing the trees into bearing are to all intents and purposes the same per acre, whether they are high-yielding or low-yielding.

THE DEVELOPMENT OF IMPROVED HIGH-YIELDING PLANTING MATERIAL is thus in the forefront of the Institute's work. It is not for us to concern ourselves with the possible effects on the prosperity and organisation of the Malayan rubber-growing industry as a whole, arising from the widespread use of such material, if such use causes potential production to outrun consumption. The estates that lower their costs of production most with the aid of improved planting material will be those which can best withstand the effects of economic adversity.

Work in this field involves the simultaneous and co-ordinated study of selection, breeding and propagation problems, the relation

between which in the work of the Botanical Division is well brought out in the report of that Division. A subject in this field which has not hitherto received much attention is the relationship between yield of stock and yield of scion; a method for the vegetative propagation of stocks might assume considerable importance in the event of a pronounced effect of stock on scion being found.

The work on TAPPING PROBLEMS is second in practical importance only to the work referred to above. The cost of tapping at present represents roughly one third of the total estate costs of production per pound of raw rubber, so that methods of reducing the cost of tapping without prejudicing yields are well worthy of investigation. The study of methods of tapping budded rubber so as to take the fullest possible advantage of its superior yielding-power without attendant disadvantages is another subject of major importance.

Reference has already been made to the collaboration between the Soils Division and the Botanical Division on ecological work, particularly in connection with covers in their relation to the soil and the rubber trees. The influence of soil and other environmental conditions on the choice of clones for replanted areas or for new plantings is also a matter of increasing practical importance.

For reasons similar to those adduced in discussing the work of the Soils Division, a major part of the work of the Botanical Division also consists of *experiments in the field*, both at the Experiment Station and on estates. More than half of the experiments in the experimental planting scheme under the International Rubber Regulation Agreement are under the control of this Division, and take up a large share of its time. However, with the addition of two Botanists to its staff in the latter part of 1937, fundamental work on the *physiology of Hevea* can now be actively pursued. The experimental work on tapping, referred to above, also has important bearings on the study of the formation and functions of latex in the tree, in addition to its immediate practical aspects.

COLLABORATION WITH OTHER DIVISIONS has been dealt with above in part. Close collaboration with the Soils Division is also necessary in connection with root studies, in at least two directions. First, there is the influence of the kind of soil and of soil conditions generally on the root-system of the plant; second, a study of the distribution and the growth of the root-system has important bearings on the study of the time and mode of application of fertilisers. The root studies in this Division also have a close bearing on the work in the Pathological Division

on root-diseases. Co-operation with the last-named Division is also necessary in connection with the work in the Botanical Division on bark-morphology and on leaf-structure, which has obvious bearings on the study of diseases of the tapping panel, and of pests and diseases of foliage.

The ALLOCATION OF THE WORK AMONG THE GRADUATE STAFF of the Botanical Division is as follows (the numbers under their names indicate the percentages of their time devoted respectively to advisory and research work in 1937):—

<i>Mr. C. E. T. Mann</i> (66A:34R)	...	Work on vegetative propagation. Study of buddings of well-known clones used in commercial planting. Special supervision of physiological work.
<i>Mr. C. C. T. Sharp</i> (29A:71R)	...	Selection and breeding work.
<i>Mr. E. R. Guest</i> (100R)	...	Tapping investigations. (Economic and physiological aspects).
<i>Dr. E. D. C. Baptist</i> (5A:95R)	...	Physiological work. Nutrition and root studies. Stock-scion relationships.
<i>Mr. N. Wright</i> (22A:78R)	...	Advisory work, and supervision of experimental work on estates, particularly in connection with the experimental planting scheme.
<i>Mr. K. N. Kaimal</i> (1A:99R)	...	Anatomical studies. Identification and description of cover plants and indigenous plants. Assists Mr. Mann in work on study of buddings. (See above).
<i>Mr. T. V. Vaidyanathan</i> (100R)	...	Assists Mr. Sharp in selection and breeding work.

There can be no clear line of division between the work of the Head of the Division and that of his staff; this is particularly so in the case of Mr. Wright and of Dr. Baptist. Much of their work is done jointly with, and so as to be interchangeable with, that of Mr. Mann.

Pests and Diseases

Malaya is fortunate, in that PESTS AND DISEASES OF HEVEA are relatively unimportant in comparison with other economic crops elsewhere, and even, in some respects, in comparison with Hevea

in some other countries. For most of the more commonly-occurring ills to which *Hevea* is nevertheless subject in some degree in Malaya, efficient and economic control measures are available, having been either developed by the previous work of the staff of the Institute, or adopted as a result of work elsewhere. Hence, although the staff of the Division is fewer than in other Divisions, the Institute is able to fulfill adequately its obligations to the industry in respect of advisory work on pests and diseases, and to conduct appropriate research and experimental work on a sufficient scale.

The relative incidence of many pests and diseases of *Hevea* varies from year to year, and from district to district, and so long as the present state of affairs continues, the Division can concentrate its attention in turn on whichever trouble is most in need of it at any one time, without undue neglect elsewhere. Should some hitherto relatively unimportant or unknown pest or disease seriously threaten to assume epidemic proportions, the position would be quite different, and the number of staff in the Division might have to be increased.

There is at present, for example, no *entomologist* on the staff, and the suggestion has been made that one is needed. Insect pests are however of such relative unimportance that the full-time employment of an entomologist cannot be justified. Adequate control measures are available for such insect pests as do occur, and the advice and co-operation of the Entomological Division of the Department of Agriculture is at our disposal when needed.

One result of the present situation is that a larger share of the time of the staff is devoted to advisory work, than is the case with other Divisions. Experimental work in the field is however fairly represented in the programme, particularly in connection with root-disease problems; study of the biology of *Hevea* diseases and pests, their symptoms, and their effects on the host, as a basis for improvements in their control, is also being steadily pursued.

The group of diseases of *Hevea* of probably the greatest importance in Malaya is that of *root diseases*, and it is therefore proper that most of the time of one member of the graduate staff should be devoted to that subject. A development of this work is the proposed commencement of experiments to study the influence of starch reserves in the severed root-system, on susceptibility to root-disease attack, and the effect of frill-girdling, with or without poisoning; this work is a logical development from the results of Leach on *Armillaria* in Nyasaland.

With regard to underground pests, the fears of a serious extension of the *cockchafer grub* have not been fulfilled, and the

promising results already obtained in the control of this pest by soil-fumigation seem likely to lead to a practicable and economic control method. The *termite pest* is a chronic rather than an acute trouble on estates. Considerably improved control by means of arsenical dusts injected into their runs appears to be possible, and is being actively studied.

Mouldy rot is one of the most important above-ground diseases of Hevea. Much can be done to lessen the attack of this disease by proper cultivation conditions, aiming at better circulation of air and avoidance of undue humidity. When this is done, proper treatment of the tapping panel with approved fungicides effects satisfactory, if somewhat tedious control. From the very nature of the case, with fresh susceptible tissues being exposed at every tapping, it is difficult to see how the present methods of frequent external applications of fungicide can be simplified or improved. A conceivable means would be the injection into the tree of a substance which would protect the tissues from attack after they were exposed, but so far no such method has been discovered.

COLLABORATION OF THE PATHOLOGICAL DIVISION WITH OTHER DIVISIONS has already been referred to in the notes on the work of the Soils Division in connection with the work on nodule-bacteria of leguminous cover crops, to which may be added the work on numbers of soil bacteria; and in the notes on the work of the Botanical Division in connection with the relation between bark and leaf structure and their susceptibility to attack; and in connection with root studies and root-disease. Other directions of co-operation with that Division are in connection with the variations of clones in their susceptibility to pests and diseases. Collaboration with the Chemical Division is in connection with the investigation of latex bacteriology and the study of various methods of latex preservation.

The ALLOCATION OF WORK AMONG THE GRADUATE STAFF of the Pathological Division is as follows. (The numbers in brackets under their names indicate the percentages of their time which were devoted respectively to advisory and research work in 1937):—

Mr. F. Beeley (47A:53R)	...	All work on <i>above-ground</i> pests and diseases; microbiological problems of soils, manures, latex and raw rubber.
Mr. R. P. N. Napper (58A:42R)	...	All work on <i>below-ground</i> pests and diseases, (particularly root-disease).
Mr. K. P. John (5A:95R)	...	Laboratory culture work on micro-organisms.

Chemical and Technological Problems

THE WORK OF THE CHEMICAL DIVISION will here be considered in its general and broader aspects.

ESTATE METHODS FOR THE CONVERSION OF FIELD LATEX INTO SMOKED SHEET,—the form in which the greater part of the world's production of raw rubber is at present used by the manufacturer—have now been developed so far that, whilst further progress is certainly possible, such progress will probably be slow, and of relatively small importance compared with the scope for improvement in other branches of estate practice.

The other aspect of the work of the Division which is specially related to the use of rubber by manufacturers at the present time is in connection with variability, which is further discussed below.

Were these two lines of work, both matters specially to do with *existing uses* of rubber, the only ones of concern to the Division, it would need less staff than it has. Actually, however, much of the work of the Division is concerned with the search for *new uses* for rubber. Such work is primarily *consumption research*. Hitherto such work has been carried out in close co-operation with the scientific staff of the London Advisory Committee, most of whose work is in the field of consumption research, and much of it in the field of "new uses."

Funds derived from the cess paid by Malayan rubber growers have now been set aside for financing, under the auspices of the International Rubber Regulation Committee, a new British research organisation, the *British Rubber Producers' Research Association* (B.R.P.R.A.), which is intended to devote its activities primarily to the search for new uses for rubber. The relations between this new body and the Chemical Division of this Institute, as well as between it and the L.A.C. are of considerable importance, with regard to co-operation in work on new uses.

It cannot be gainsaid that the centre for consumption research, and therefore for work on new uses, is best situated in the actual or potential consuming countries, and that the main field of work of the R.R.I. must be in *production research*. Certain aspects of consumption research must however be dealt with in Malaya. Latex is being used to an increasing extent in various new or improved applications in the rubber-manufacturing industry, and all problems of concentration or preservation of latex for export, which are obviously problems that must be studied in the country of origin, are therefore consumption research problems which must figure in the R.R.I.'s programme. Other directions in which improved applications or new uses of rubber will be sought may

necessitate modifications in the raw material which can only be brought about, or which can more readily be brought about, if applied to fresh unpreserved latex, whether the raw material is then to be exported in the liquid or solid form. Much of the work dealt with in the report of the Chemical Division concerns consumption research arising from the above questions, whilst Dr. Robert's work on the chemistry of latex may also be expected, as one of the various possible outcomes, to point the way to new modifications of or uses for rubber. It is hoped that there will be a constant interchange of programmes and reports between the B.R.P.R.A. and the R.R.I., as two complementary producers' research organisations, in the same way as there is at present between the L.A.C. and the R.R.I., and has been hitherto between the R.R.I. and the R.G.A.

The problem of *variability* in latex and in raw rubber, together with its bearings on the possibility of *standardisation*, is a matter regarding which a complete understanding does not yet exist, as between the Institute, as representing the producers, and the manufacturers. Active steps were taken in 1937 to obtain an agreed definition of the manufacturers' requirements. Meantime, before the feasibility of attempting to eliminate variability in latex and raw rubber can be judged, it is necessary to study the factors involved, and the extent of the variability met with in practice; and to discriminate between variability arising wholly from the methods of processing field latex on the estates, which is capable of being controlled; and that arising from uncontrollable factors inherent in the trees or conditioned by variations in their environment (soil, climate etc.), which may possibly, but by no means certainly, be capable of being "ironed out" in the estate factory. Much of the work of the Division is directed towards a comprehensive study of this question.

THE FUNDAMENTAL WORK ON THE CHEMISTRY OF LATEX has important bearings on the fields of work above discussed: new uses, and variability. It also has most important bearings on the study of the functions of latex and the mode of origin of caoutchouc in the tree.

COLLABORATION OF THE CHEMICAL DIVISION occurs primarily with the L.A.C., but also with the Botanical Division and the Pathological Division as mentioned already in the notes on the work of those Divisions.

THE ALLOCATION OF WORK AMONG THE GRADUATE STAFF of the Chemical Division is as follows (the numbers under their names

indicate the percentages of their time which were devoted respectively to advisory and research work in 1937):—

<i>Dr. E. Rhodes</i> (61A:39R)	...	Latex-preservation, latex-technology, and small-scale investigations on latex-concentration (with Mr. Sekar). Latex-bacteriology (with Mr. F. Beeley, Pathological Division).
<i>Dr. K. C. Roberts</i> (100R)	...	Purely chemical investigations, of latex and raw rubber.
<i>Mr. J. D. Hastings</i> (4A:96R)	...	Technology of rubber.
<i>Mr. J. H. Piddlesden</i> (49A:51R)	...	Estate technique. Large-scale preparation of special latex and latex-concentrates; efficiency-testing of plant.
<i>Mr. A. Moore</i> (For first 4 months of 1937 only) (93A:7R)	...	Advisory work.
<i>Chemist to be appointed*</i>		Special and modified rubbers.
<i>Mr. K. C. Sekar</i> (33A:67R)	...	See Dr. Rhodes.

Mr. Piddlesden has taken over the advisory work of the Division formerly done by Mr. Moore. The new chemist to be appointed will eventually be required to take over the technological work on rubber during absences of Mr. Hastings on leave and he will be expected to take an interest in this work from the time of his arrival. For this reason the chief item of research allotted to him is that on modified rubbers. Vulcanisation tests play a major part in deciding the suitability or otherwise of the products obtained in this work and he will therefore be thrown into close touch with Mr. Hastings' work from the start and should later be able easily to deputise for him. If it should transpire that Mr. Piddlesden's free time from advisory work is too broken, the new chemist will also be able to supervise for him the work on batch preparation of special latex and concentrates.

Experiment Station

The experimental work at the Station is dealt with in the reports of Divisions as a part of the programme of work of each,

* *Mr. V. H. Wentworth, B.Sc., A.I.C., A.I.R.I. (Sc.), A.R.Ae.S.I. took up this appointment on 6th May, 1938.*

and in the report of the Manager from the point of view of the practical work involved.

The planted area increased by 61.5 acres in 1937, and the area in tapping increased by 96 acres to 527.25 acres. The reserve area has been reduced to 174.45 acres, part of which will be planted in 1938.

It is satisfactory to note that the general manuring applied to certain areas in 1936 has had a marked effect in improving the foliage of the trees. An extension of this general manuring programme to the rest of the Station (other than on manuring experiments) has been decided upon.

Reference to the details of fields in tapping in the Manager's report will show that cup-coagulation is used for a large proportion of the latex. This is a necessary feature of much of the experimental work, where individual tree records are required, and the proportion of the Station's output to be produced in this form is likely to increase. This introduces difficulties in the sale of produce, and somewhat reduces the income of the Station.

The very marked increase in the number of visitors to the Station which occurred in 1936 was well maintained in 1937, when the recorded number was 568, including six parties from branches of the Incorporated Society of Planters, a number of scientists and planters from the N.E.I. and Ceylon, and many directors of rubber-producing companies from Europe. Indian, Chinese and Japanese visitors were well up to the previous year's number, and a pleasing feature was the number of visits from Malay small-holders.

Increased advantage was taken of courses of instruction to conductors from estates; 50 conductors were so instructed.

Shows

An exhibit was staged at the Exhibition of the Malayan Agri-Horticultural Association in Kuala Lumpur in August; the arranging, staging and judging for the All-Malaya small-Holders' rubber competition at that Exhibition was also undertaken by officers of the Institute. The new buildings of the Institute, only a short distance away from the show-ground, were thrown open to visitors during the three days of the exhibition; special exhibits were staged in the laboratories and Research Officers were on duty to demonstrate to visitors. A total of 307 people visited the Institute during the show, including 42 Europeans, 24 Malays, 127 Chinese and 112 Indians.

At eighteen State or district agricultural shows and rubber competitions exhibits were staged by the Institute, and most of these were visited by officers of the Institute. I attended the shows at Peringat (Kelantan), Muar (Johore) and Telok Anson

(Perak). A welcome improvement in our exhibits was the provision of descriptive labels in Malay (Jawi), Chinese and Tamil as well as in English.

Publications and Library

The following publications were issued during the year:

- (1) Journal of the Rubber Research Institute of Malaya, Vol. 7, No. 2.
- (2) Journal of the Rubber Research Institute of Malaya, Vol. 8, No. 1.
- (3) Annual Report, 1936.

(4) Illustrated booklet describing the Institute and its work. This was issued on the occasion of the throwing open of the Institute during the M.A.H.A. Exhibition, and a revised edition was issued in September.

During the year 63 books were added to the Library, excluding pamphlets and scientific periodicals, of which the number regularly subscribed to is 89.

A number of instructional leaflets were prepared in each Division for use in dealing with advisory enquiries.

Visitors

The visitors' book records 548 visitors in the year, a marked increase over the figure of 398 for 1936. Not included in this number are either the about 450 visitors on the occasion of the official opening of the Institute on May 19th or the 307 visitors to the Institute during the M.A.H.A. exhibition. Including these, and the 568 visitors at the Experiment Station, the Institute as a whole received a total of nearly 1,900 visits.

A list of visitors from outside Malaya is shown in an Appendix to this report.

General

I have continued to serve on the Advisory Committees of the Department of Agriculture, S.S. and F.M.S. and of the School of Agriculture, Malaya; on the Inter-departmental Marketing and Propaganda Committee; and on the Public Gardens Committee, Kuala Lumpur.

In conclusion, I am glad to express my appreciation of the loyal and whole-hearted assistance which I have received from all members of my staff.

I also record with pleasure the cordial relations and friendly co-operation which my staff and I have enjoyed with the Director and Adviser on Agriculture, S.S. and Malay States, and his staff, and with the Controller of Rubber and his staff.

H. J. PAGE

Director

Kuala Lumpur,

25th June, 1938

APPENDIX

Analysis of Correspondence by Divisions

BOTANICAL DIVISION

Subject	Letters Received	Letters Despatched
I. Budding.		
General. Advice on choice of clones.		
Clone Records	373	418
Training of Conductors and Pupils from Estates, etc.	1	1
Field Experiments (Estate Trials) ...	2	2
Growth of Budded Trees	3	2
Packing and Treatment of budwood	2	3
Special materials	1	1
	382	427
II. Tapping.		
Estate Enquiries. General	78	98
Estate Experiments General	28	21
Estate Enquiries (Tapping of Budded Trees)	75	78
Estate Experiments (Tapping of Budded Trees)	167	122
Test Tapping of seedlings	7	6
	355	325
III. Selection. Individual Mother-Trees.		
Selection on estates	2	3
Latex-Vessel and Bark Examinations	3	5
Isolation Gardens	20	29
Seed Germination	2	2
Seeds for Experimental purposes ...	2	3
Requests for seeds	4	3
Identification of seed	1	1
Oil extraction from seed	1	1
	35	47
IV. General Planting Enquiries.		
Information on planting Operations	6	7
Replanting	278	321
Cover Plants	79	112
Thinning	1	1
Catch crops	2	1
	366	442
V. Special Enquiries in connection with Rubber Assessment	29	16
VI. Planting of Experimental Areas on estates under the Rubber Regulation Scheme	527	634
VII. Apparatus	8	8
VIII. Miscellaneous	35	50
GRAND TOTAL	1,737	1,949

CHEMICAL DIVISION

Analysis of Correspondence, 1937

Subject	Letters received	Letters despatched
Latex	21	44
Latex Preservation	89	116
Latex Concentration	62	70
Latex—Instruments for determining D.R.C. ...	134	135
Anti-coagulants of Latex	18	16
Anti-oxidants of Latex	1	1
Coagulation	33	34
Coagulating Tanks and Pans	8	8
Rubber Preparation—General Enquiries ...	18	21
Smoked Sheet	136	208
Crepe Rubber	14	19
Sole Crepe	1	1
Raw Rubber Powder	3	4
Water Samples	11	20
Machinery for Rubber Manufacture ...	60	87
Smoke-houses	129	168
Vulcanisation of Rubber	38	48
Accelerators for Vulcanisation	10	9
New Uses of Rubber	15	17
Softened Rubber	4	5
Rubber Substitutes	4	4
Rubber Paving for Road Surfacing ...	11	12
Rubber Paints	1	1
Rubber Seed Oil	3	3
Patents	17	21
Orders for Chemicals, etc.	21	11
Apparatus	49	53
Miscellaneous	15	14
Correspondence with Manager Experiment Station	—	11
Materials for Laboratory Use	1	1
TOTAL ...	927	1,162

PATHOLOGICAL DIVISION

Analysis of Correspondence 1937

Subject					Letters received	Letters despatched
Root Disease	...	...	...	...	173	205
Stem and Branch Disease	...	...	...	...	78	90
Leaf Disease	...	...	...	...	292	278
Fungicides and insecticides	...	...	...	...	92	116
Insect Pests	...	...	...	...	679	468
Brown Bast	...	...	...	...	3	5
Spraying and Dusting equipment	...	...	...	...	7	11
Disease—general treatment	...	...	...	...	29	43
Replanting	...	...	...	...	13	13
Lightning Damage	...	...	...	...	8	12
White ant treatment	...	...	...	...	33	39
Sulphur Dustings	...	...	...	...	1	3
Miscellaneous	...	...	...	...	96	145
Requests for Legume Cultures	...	...	...	...	4	7
TOTAL					1,508	1,435

SOILS DIVISION

Analysis of Correspondence 1937

Subject	Letters received	Letters despatched
Cultivation—General Enquiries	3	5
Forestry Methods	4	7
Experiments	24	29
Cover Crops and Natural Covers—		
General Enquiries	93	107
Manuring	10	11
Eradication by Weed Killers	8	8
Seeds	15	13
Manuring	518	684
Soil Conservation and drainage	3	3
Catch Crops	1	1
Replanting	222	312
Fertilisers	30	27
Soil samples	42	33
Experimental planting under the Rubber Regulation Scheme	283	408
Apparatus	9	13
Leaf—analysis	15	37
Miscellaneous	50	65
TOTAL ...	1,330	1,763

APPENDIX

Staff Movements in 1937

Officer	Appointment	Assumed duty	Returned to duty	Went on Home-leave
F. Beeley	Pathologist		7th January	
J. D. Hastings	Chemist		29th July	
N. Wright	Botanist	14th August		
R. F. Harley	Assistant Expt. Stn.	27th August		
A. W. J. Dyck	Soils Chemist	7th October		
E. R. Guest	Botanist	11th November		
H. Fairfield Smith	Statistician	19th November		

A. Moore was transferred from Chemical Division to become Personal Assistant to the Director on 23rd April, 1937.

APPENDIX

Visitors from outside Malaya during 1937

- C. C. Ament, Batavia, Java.
 F. D. Ascoli, Dunlop Plantations Ltd., London.
 D. T. Angus, Ceylon.
 J. E. Barrs, Newton Chambers & Co., Ltd., Sheffield, England.
 H. E. M. Bumpus, Boekit Mas Estate, Sumatra.
 W. N. Bangham, Goodyear Rubber Plantations Co., Serbalawan, Sumatra.
 E. Bateson, Controller of Rubber, Mycologist and Agricultural Adviser,
 Jesselton, B.N.B.
 N. C. S. Bosanquet, Bosanquet, Trail & Co., London, E.C.3.
 T. B. Barlow, Thomas Barlow & Bro., London, E.C.
 C. Barclay, H.A.P.M., Sumatra.
 S. C. E. Bloom, Djaboong, Wlingi, Java.
 W. S. Cookson, Sumatra.
 H. F. Copeman, Rubber Estate Agency Ltd., London, E.C.3.
 C. H. D. Curtoys, Shanghai.
 P. J. S. Cramer, Wassenaar, Holland.
 G. Cumming, Hatherleigh, Rakwana, Ceylon.
 L. Chalk, Imperial Forestry Institute, Oxford.
 J. F. H. Cronshey, H.A.P.M., Sumatra.
 F. P. Coyne, Imperial Chemical Industries Ltd., London.
 W. E. Cake, H.A.P.M., Sumatra.
 M. T. Castillow, Cuthbert, Ga., U.S.A.
 R. Cary, M.P., House of Commons, London.
 A. H. Chilton, London.
 F. C. Driessen, I.C.H.V.R., Batavia, Java.
 L. R. Dunne, Adelaide, Australia.
 O. C. Furness, Doulton & Co., Ltd., London.
 K. D. H. Gwyn, Nagahatenne, Elpitiya, Ceylon.
 J. Grantham, H.A.P.M., Sumatra, and Downing College, Cambridge.
 A. S. Haynes, England. (Formerly M.C.S.)
 J. Iwata, Tokyo, Japan.
 E. J. Joachim, Pontianak, Dutch W. Borneo.
 J. S. H. Jolliffe, Ceylon.
 Thos. L. Jackson, Pullangode Estate, S. India.
 Y. Kawabata, Danau Salak Estate, Bandjermasin, Dutch Borneo.
 Kinji Kaneda, Kobe University of Commerce, Kobe, Japan.
 M. D. Knapp, H.A.P.M., Sumatra.
 G. G. van Kooy, Societe Financière des Caoutchoucs, Medan.
 F. Laeblein, I. G. Farbenindustrie, Berlin.
 W. Leech, London.
 E. M. McColm, H.A.P.M., Sumatra.
 L. A. Mills, Canada.
 J. de W. Mayer, Manila, Philippine Islands.
 J. R. D. and J. M. Malkin, Vancouver, Canada.
 Jawaharlal Nehru, Allahabad, India.
 R. Milligand, Oamaru, New Zealand.
 G. D. P. Olds, Agricultural Officer, Brunei and Labuan.
 H. F. Pearson, Ceylon.
 R. H. le Pelley, Department of Agriculture, Nairobi, Kenya.
 A. F. Patterson, Colombo, Ceylon.
 B. Platt, Lester Institute, Shanghai.

- A. J. Ritchie, Gardiner, Hunter & Co., London.
- G. Maxime Robert, Banque de l'Indochine, Indochina.
- L. Shannon, Madras.
- T and Y. Senda, Tokio, Japan.
- W. Schmidst, I. G. Farbenindustrie, Berlin.
- H. J. Van Holst Pellikaan, Controller of Rubber, Netherlands East Indies, Batavia, Java.
- M. Van den Abeele, Director-General, Colonial Office, Brussels, Belgium.
- H. S. Venkata Rao, Mysore State, India.
- A. M. M. Vellayan Chettiar, M.H.R., Burma, Rangoon.
- C. A. Wismer, Firestone Plantations, Monrovia, Liberia, Africa.
- R. Wauters, Societe Financière des Caoutchoucs, Medan.
- C. N. C. Williams, Burma.
- H. N. Whitford, Rubber Manufacturers Association, New York.
- A. N. Wyes, New York.
- E. H. and A. Y. Weigall, S.O.L. Miri, Sarawak.
- J. Wilson, Director of Research, British Rubber-Producers' Research Association, London.
- E. Yokata, Tawau Rubber Estate, Tawau, B.N. Borneo.

ANNUAL REPORT

SOILS DIVISION

A very marked expansion of the work of the Soils Division occurred in 1937 and this necessarily followed from the programme of work designed for the year. As well as extensions of laboratory work, a large number of field experiments on estates were planned and the conception of these experiments arose partly from the opportunities offered under the Rubber Regulation Scheme for experimental planting of reserve jungle land and partly from the adoption of a more active policy in this Division regarding the development on rubber estates of experiments which are partially or wholly, by agreement, under the control of the Institute. The after-effects of the fire of 1936 and the complicated process of settling into new laboratories appreciably curtailed the laboratory investigations, but experimental work on estates expanded according to programme, involving all members of the Division in much additional work as well as necessitating staff increases.

Staff

During the year, a change in the European personnel took place. Mr. A. Moore, who had been an advisory officer attached to both Soils and Chemical Divisions, in April was transferred to be Assistant to the Director, but it was not possible to fill this vacancy until 5th October, 1937, when Dr. A. W. J. Dyck arrived and assumed duty as Soils Chemist.

Increases in all classes of the junior Asiatic Staff, to the extent of eleven new appointments, were made during the first half of the year.

Laboratory Work

Removal to the new laboratories and the assembling of new equipment occupied the early months of the year, and although the actual occupation of the new premises took place in March, normal working was not possible until the end of May. The only apparatus with which difficulties were experienced was the pH instrument (glass-electrode type) which had to be returned to the makers for overhaul because consistent readings could not be obtained. The lack of steam until late in the year was another minor handicap, preventing the use of steam baths and of the water-distillation apparatus; the Division is indebted to the Institute for Medical Research for the loan of an electrical water-still.

Owing to the accumulation of samples (of soil profiles and rubber leaves) during the period following the fire of September, 1936, efforts were concentrated on reducing these arrears of analyses, the results being required particularly for classifying rubber soil types and in connection with field experiments now in progress, and as a consequence, laboratory research work, apart from these determinations, was not very extensive.

About 430 soil samples from profiles were analysed, involving some 3870 determinations, and about 660 leaf samples, involving 4620 determinations, were examined. Other analytical work was carried out in connection with research work.

Advisory Work

CORRESPONDENCE

The total amount of correspondence was still very considerable, numbers of letters being approximately the same as in 1936; the subjects of most enquiries received were: manuring, replanting, leguminous covers and experimental planting. An analysis of the correspondence will be found appended to the Director's report.

VISITS

The number of visits made to estates was again high (262), and of these, 113 were in connection with experimental work. The R.R.I. Experiment Station was visited on 10 occasions.

Prolonged tours outside Selangor were made on 23 separate occasions, their distribution among estates being: Johore, Perak, Negri Sembilan, 5 each; Kedah, 3; Malacca, Pahang, 2 each; Kelantan, 1.

EXHIBITIONS AND SHOWS

In addition to attendance at the Malayan Agri-Horticultural Association Exhibition, members of the Soils Division were present at the District agricultural shows which were held in July at Klang and at Seremban.

LECTURES

During the year the following lectures were delivered by members of the Division:—

C. G. Akhurst

- (1) on 4th April, 1937; "Replanting", to North Johore Branch, Incorporated Society of Planters, at Genuang
- (2) on 14th July, 1937; "Replanting", to Seremban—Rantau—Port Dickson Branch, Incorporated Society of Planters, at Seremban

- (3) on 20th July, 1937; "Replanting;" to Tanjong Malim Branch, Incorporated Society of Planters, at Tanjong Malim
- (4) on 17th September, 1937; "Replanting;" to Kelantan Branch, Incorporated Society of Planters, at Kuala Krai.

R. A. Hamilton

- (5) on 25th May, 1937; "Coastal clay and peat soils;" to Lower Perak Branch, Incorporated Society of Planters, at Teluk Anson.

A. Moore

- (6) on 8th January, 1937; "Replanting;" to Sitiawan Branch, Incorporated Society of Planters, at Sitiawan
- (7) on 17th February, 1937; "Replanting;" to Kedah Planters' Association, at Sungei Patani.

Covers

ESTABLISHMENT OF LEGUMES

In the past year considerable interest by estates has been shown regarding the establishment of leguminous covers under mature rubber trees and a number of experiments on estates have been started to compare the effects of various fertilisers and different cultivation methods. Laboratory and field experiments were also carried out to investigate the value of inoculating cover-crop seed with root-nodule organisms before sowing in the field, and more detailed mention is given of this work below.

Leguminous covers can grow in healthy mature rubber-tree areas, as is indicated by the number of patches of covers, varying from a few square yards up to a few acres in extent, which occur on various estates throughout the country, but no definite results from the experiments mentioned above can yet be stated, which will define the precise conditions required for successful growth of the covers. The factors which have to be taken into consideration are competition from the rubber-tree roots for water and plant foods, the effect of overhead shade from the rubber-tree foliage, the presence in the soil of suitable types of nitrogen-fixing organisms which will ensure nodulation on the cover-plant roots, the effect of cover-crop fertilisers and also the value of lime as an aid to encouraging bacterial growth.

The indications at present are that initially manuring with a light application of a fertiliser supplying nitrogen, phosphorus and potash is necessary, followed later by dressings of rock phosphates; creeping covers are more satisfactory than bushes;

trenched squares are required for effective elimination of rubber-tree roots-competition; inoculation of the cover-crop seed, prior to sowing, may help to ensure good growth.

The cost of establishing legumes under these conditions may vary between \$5/- and \$10/- or more per acre, and for expenditure at the higher limit to be justified one must be certain that the expenditure is commensurate with the benefits given to the rubber trees.

Theoretically, healthy and vigorous leguminous covers should have the particular benefit of increasing the nitrogen-content of the soil. There is no experimental evidence available at present, for Malayan conditions, which confirms this theoretical advantage of legumes or that rubber trees benefit any more from the presence of leguminous covers than they do from that of non-leguminous and indigenous covers. Until this evidence is available, heavy expenditure on the establishment of legumes in mature rubber areas should be approached cautiously and made freely only in areas where it is essential to have a ground-cover and where indigenous covers fail to appear.

Similar experiments have been commenced to study the establishment of leguminous covers in replanted areas. Phosphate manuring again appears to be of prime importance, and the addition of smoke-house ash, as a cheap source of potash, is of value too.

In areas of young trees on the R.R.I. Experiment Station, where tapping was commenced about a year ago, *Desmodium ovalifolium* has been established very readily on hill land, in spite of quite dense overhead shade. Cuttings were planted, without any measures being taken to eliminate competition from the rubber-tree roots (the latter however are not so dense as in a normal mature area), and no manuring was done.

RETARDATION OF GROWTH OF YOUNG RUBBER TREES BY COVERS

In last year's Annual Report, observations were reported on the retardation, by bush legumes, of replanted rubber trees during early stages of growth, owing to the root systems of the legumes developing into the planting-holes. From growth-measurements recently reported it appears also that bush-covers may cause a very appreciable growth-retardation owing to their shading effect, and where bush-covers are being grown in areas of young rubber plants any suggestion of overshadowing should receive immediate attention. In practice this means that from 3 ft. to 4 ft. around each planted point, bush covers should either be eradicated or cut below the height of the rubber trees.

The retarding effect on the growth of young rubber trees by heavy ground-covers if left uncontrolled is well known, and an interesting aspect of this was revealed in an estate experimental area. On half the experiment (Section A) a cover of *Centrosema pubescens* had been established for more than a year prior to planting with rubber stumps, and on the remaining half, (Section B), *lalang* was removed immediately prior to planting and *C. pubescens* was put in about four to six months later. During the first year, normal circle-weeding (4ft. circles) was maintained throughout the whole area, and after 12 months the average height in Section A was 7.35 feet, whereas in Section B it was 9.70 feet. This difference in height of 2 ft. 4 ins. is attributed to the vigour of the root system of the pre-established cover. Normal weeding maintained the surface clean, but the cover roots were able to maintain themselves several inches below the soil surface and by competing for plant foods and soil moisture seriously to hinder the root development of the rubber plants. This was verified by examining the cover plant underground root systems. The retardation in growth had not appeared at six months after planting.

This experience indicates that a modification in weeding methods in young areas might be introduced. Weeding circles or weeding strips, which are gradually enlarged as the young rubber plants develop, should receive a treatment of "vertical slicing" into the soil, to a depth of 6 inches, in order to sever the cover-crop roots which enter the area where the rubber plant roots are developing. Such a procedure need not be followed at every weeding round and can be given up when the rubber-tree roots are thoroughly well developed. At the same time excessive damage to the rubber roots must be avoided. The cost of this treatment should not exceed about 70 cents to 80 cents per acre per round.

COVERS IN REPLANTED AREAS

Similarly, on any areas of land which have been under heavy leguminous creepers for some time prior to the planting or replanting of rubber trees, the cover should in the first place be dug in along the planting rows about a month before the new planting is done, and the future weeding should include "slicing" at intervals.

In areas of old rubber trees, about to be replanted, where grasses have been long established the problem of how best to remove the grass and replace it by a legume has arisen on several estates. Complete weeding of the grass in monthly rounds, until the legume is well established proves very expensive, and the

most satisfactory treatment is to plant a vigorous cover, *e.g.* *Pueraria javanica*, in small cleared patches of 3 ft. to 4 ft. diameter, to provide adequate manuring, and to confine weeding to these patches. Circle- or strip-weeding for the new rubber plants is done as well, and the creeper in six to twelve months chokes out most of the grass. In this way heavy weeding costs and undue soil disturbance are avoided.

"NATURAL" COVERS

No new developments are to be reported in connection with the use of indigenous plants as covers on rubber estates. Uncontrolled growth of approved natural bush covers has been observed to affect adversely the foliage of rubber trees owing to the intensive root competition which has been produced, the forestry growths on the estate in question being nearly as tall as the rubber trees themselves.

Observations on experimental areas show that on land of moderate slope, complete removal of undesirable covers produces an improvement in rubber-tree foliage which lasts for at least three to four years, and that clean-weeding over this period does not cause any obvious deterioration in comparison with similar trees under controlled forestry.

When manuring is being carried out in fields which have a well-established system of indigenous covers there is, temporarily, need for a more severe control of the plant growth than is normally given and this is considered in some detail under the heading of Manuring.

During a tour in Kelantan a peculiarly local plant-growth to be seen was a "mistletoe" plant (*Loranthus* sp.) which grows comparatively profusely on rubber trees in that part of Malaya. Numerous instances of extensive dieback were seen which had been caused by this parasitic growth, and the remedy of cutting out the dead wood frequently resulted in almost complete loss of the crown of the tree. References to this plant have been made in the *Malayan Agricultural Journal*, 1924, Vol. 12, as well as in earlier numbers of the *Agricultural Bulletin*; a large number of species occur. It is almost certainly spread by birds which, after feeding on the berries, drop the seeds on to the branches of other trees, and it seems probable that the extensive monsoon period in Kelantan is particularly favourable to the plant. The best method of control is to cut out the sprays of mistletoe and the host branch, if possible before berries form.

In Burma, owing to the extensive dry season, natural covers are favoured which are more or less drought-resistant in order to

provide shade for the soil and to lessen the risk of fire; *Clerodendron* sp. and *Eupatorium* sp. are cover-plants which are popular in that country. The latter plant in Malaya is not considered a good type of cover, particularly in young clearings, owing to its prolific seeding and rapid spreading habit. This comparison is of interest in indicating how difficult it is to generalise regarding rubber cultivation.

Replanting

Whilst replanting is still one of the foremost planting topics, replanting programmes in Malaya in 1937 were on a no larger scale than in the previous year, and the comment made in the 1936 Annual Report must be repeated here, that the replanting actually in progress is very much below the total permissible acreage (400,000, approx.) which is available for estates other than small-holdings, the latter having replanted only a negligible acreage. One reason which has prevented a larger expansion of replanting work is the belief that planting of reserve land will be allowed at the end of the present term of the Rubber Regulation Enactment; until the conditions governing any possible new planting were known rubber companies have 'marked time' in their replanting. Whether such an attitude towards replanting can be endorsed depends very largely on the financial status of the companies concerned. It certainly should not be assumed that new planting on any virgin jungle soil will always produce better-grown trees for a smaller cash expenditure than will replanting of old rubber trees on any cultivated soil.

One other development produced by the prospects of new planting in the near future is the opening and preparation of jungle areas (as opposed to their actual planting) which has been planned by several companies for 1938. Such a procedure has several advantages:—preliminary operations before planting can be conducted without undue rush and haste; once the land is prepared the actual planting of rubber plants can be done as soon as a new Enactment permits, and there is every chance that the cost of preparing the land can be kept at a comparatively low figure.

MANURING IN REPLANTING

During 1937, a considerable amount of information was amassed from replanting trials and experiments in various parts of the country and the general conclusions which can be drawn from the results (based on height measurements at six months and twelve months from planting) are briefly as follows:—

(1) an adequate phosphate-supply is of main importance to the young seedlings, whilst nitrogen and potash are of less importance

(2) during the early months of growth, it is an advantage if part of the phosphate supplied is water-soluble

(3) there appears to be no advantage in using the more expensive forms of organic fertilisers over inorganic mixtures.

There are also indications that small dressings of fertiliser, applied at short intervals, will produce the best growth in replanted rubber, which is in accordance with observations reported from Sumatra.

Further replanting experiments were commenced in the latter part of 1937 to obtain more detailed information (a) of the relative importance of N, P, and K on different soil types; (b) the frequency and optimum quantities of fertiliser dressings; (c) the relative value to young plants of soluble and insoluble forms of phosphatic manures; (d) the value of digging-in cover-plants.

A standard scheme of manuring has been drawn up and is recommended for replanting on typical inland soils (loams derived from Raub Series, granite and quartzite rocks). Modifications to this programme are necessary when sandy, peaty or coastal clay soils are being considered.

GENERAL

Several points of general interest have emerged from inspections of numerous replanted areas. In coastal districts where winds are more vigorous and persistent than farther inland, it has been suggested that bush-covers, at least during the first two years of growth, may be of special benefit to the young rubber seedlings and buddings because they function as a wind break. Provided the soil can be covered and protected from erosion equally well by either bushes or creepers, the extra protection from high winds offered by belts of bush covers certainly makes it an advantage to use them.

Again, unusually dry weather experienced in many parts of the country during the last months of 1936 and the early part of 1937 was undoubtedly the main reason for the backward condition of replantings (and new plantings) which were not completed until late December 1936 or early January 1937. This confirms previous observations that adequate rainfall is of great importance to the *young* rubber plant and that by planning to commence planting as soon as the first rains come, in September, (except in districts of abnormal weather conditions) the benefits conferred on the new plants are considerably more than one or two months' extra growth.

Far too often an attempt has to be made (by the Manager, Visiting Agent or R.R.I. officer) to estimate the progress of plants in a young clearing without any detailed records; it is

strongly recommended that, by means of annual measurements, a growth record should be kept in all replanted or newly-planted areas. Several rows or terraces, taken at random in the field, should be measured, and the average figures will simplify considerably comparisons between areas of different soils and different ages of trees.

Very little replanting by small-holders has as yet been attempted, but observations on the few areas which have commenced are being kept by Asiatic Rubber Instructors. Two small areas have been replanted by the Institute for purely experimental purposes, using a simple procedure which can be recommended, if successful, to small-holders desirous of doing replanting. One of the main problems, in this connection, is to determine the magnitude of the retardation in growth produced by overshadowing from neighbouring trees, which is to a large extent unavoidable, under small-holding conditions.

Manuring

Apart from the manuring done in replanted areas, extensive applications of fertilisers have been made to a considerable amount of mature rubber trees of varying ages in all parts of the country. The evidence available from several trials and experiments, whilst being far from conclusive, is such as to justify manuring rubber trees up to 25 years of age, and even older ones, provided certain conditions are fulfilled; briefly these conditions are as follows. If manuring is done, the full effects from the fertilisers will usually not be derived by the trees for several years, and hence areas to be manured should certainly not be amongst those likely to be considered for replanting during the ensuing five years. With this proviso, manuring usually can be expected to improve considerably the foliage and maintain the bark and yield of the rubber trees, giving in some cases a yield increase. If these effects are achieved (and it can be regarded as a considerable achievement merely to prevent any deterioration in the general condition of the trees) the period of years during which the replanted section is yielding no crop whilst attaining maturity, can be faced by the company with some measure of confidence. Again, where the yields of particular fields are low and the general vigour of the trees is poor, it may not be worth while manuring owing to the small amount of improvement which can be expected, but where to draw the line, for age above which, and for yield below which, it must be deemed uneconomic to apply fertilisers will depend very largely on local conditions on individual estates and also on the financial position and general policy of the company concerned.

In manuring old trees, it can generally be accepted that

nitrogen and phosphoric acid are the main requirements, but it is also considered advisable to include a little potash, which increases the cost only slightly and at the same time is some insurance against the displacement of balance of plant foods in the soil which is possible if potash is omitted. Thus, a "complete" type of fertiliser is now recommended for old trees, and again the experimental evidence which is available, although not conclusive, supports this recommendation. From some trials which were commenced in 1927, on 23-year-old trees, the results indicate that a period of three to four years elapsed before the appearance of any appreciable increase in yield owing to manuring, and that "complete" fertilisers have given the best results.

Attempts have been made in a few manuring experiments to measure improvements in bark due to manuring, but in only one case has an increase in bark thickness been obtained which is directly correlated with the manures applied. Bark measurements appear to be subject to several extraneous influences, such as variations, between trees, of hardness of bark, personal peculiarities of the individual taking the measurements, etc., and the figures normally obtained are of somewhat doubtful value.

A number of enquiries have been received in connection with the use of alternate-daily tapping, without resting, as opposed to more conservative tapping systems with resting periods, and whether by manuring satisfactory bark conditions can still be maintained. Whilst there is no direct evidence available, it is considered reasonable in many instances to expect manuring to produce bark improvements which will permit the heavier tapping system to be maintained.

PHOSPHATE MIXTURES AND MANURES

In general, the types of fertilisers which have been recommended for manuring rubber trees are mixtures composed of three or four manures, each supplying single plant-foods, and whilst any equivalent proprietary fertiliser will be equally effective, the use of a mixture often has several advantages. It permits much more flexibility regarding the relative amounts of nitrogen, phosphorus and potash which can be applied in a single dressing, and this is of particular value in making manuring recommendations for different ages of trees on different types of soil. It also allows the inclusion of the cheaper forms of phosphate fertilisers (*e.g.* rock-phosphates) and thereby usually the price can be kept at a minimum figure.

In fertiliser mixtures it is advisable to avoid possible losses of ammonia from the mixtures, when ammonium compounds are included, which may occur if certain types of rock-phosphate are

used. The magnitude of the loss depends partly on the proportion of rock-phosphate to the ammonium salt which is in the mixture, and also on the length of time for which the two compounds are in contact. During the first week after mixing, the losses are small (only a few per cent) but for longer periods, up to two months, they may amount to 15 per cent of the total nitrogen-content.

A number of rock-phosphates are offered for sale in Malaya and evidence is accumulating to show that, on most Malayan soils, both young and old rubber trees will respond to manuring with rock-phosphates. The value of a rock-phosphate depends upon its total content of P_2O_5 and its availability, which may depend to a certain extent upon its fineness. The following table shows for each of the rock-phosphates on the Malayan market its price per ton, its percentage content of P_2O_5 , and its fineness (as determined on samples supplied to the Institute), all of which vary considerably.

Main Types of Rock Phosphates obtainable in Malaya

Name	Current price per ton (ex-godown) \$	Content of P_2O_5 Total	Cost per unit of P_2O_5 \$	Fineness	
				120 Mesh sieve per cent.	200 Mesh sieve per cent.
Xmas Island -	33.50	38%	0.9	74	44
Safaga -	40.00	31%	1.3	86	64
Gafsa -	40.00	27%	1.5	93	63
Cheribon -	45.00	30%	1.5	81	60
Egyptian -	32.00	31%	1.0	95	67

In order to decide which is the most economical form of phosphate for use in manuring rubber trees, it is necessary to know whether one unit of the phosphate with the lowest unit price, which also happens to be the least fine, is equivalent in fertilising value to one unit of the finer and more expensive (per unit P_2O_5) phosphates or whether the higher P_2O_5 content of the former is counterbalanced wholly or partially by the greater fineness of the latter.

There is at present no definite experimental evidence on this point for Malayan rubber soils. In temperate countries fineness is an important factor in rock phosphates but it may be that this

factor is of much less importance under Malayan conditions. Experiments are being carried out to obtain further evidence on this question. Meanwhile, all of the above phosphates may safely be used at equal weights per acre or per point. If this is done, a rock phosphate with a higher percentage of total P_2O_5 will leave larger reserves of P_2O_5 in the soil than one of lower analysis, and so probably a saving may be made in the cost of later dressings.

METHOD OF APPLYING MANURES

The method of application of fertilisers to rubber trees on Malayan soils, under local conditions, has not yet received any detailed investigation and there is still considerable diversity of opinion regarding the best method to use. To give the maximum benefit to a rubber tree the fertiliser applied should affect the entire feeding root system, and with young plants it is comparatively easy to examine the root systems and mark out the approximate area on the surface of the soil which will include most of the roots. With old trees, whose feeding roots may be considered to ramify throughout the surface soil layers the ideal mode of application, therefore, is to distribute ('broadcast') the manures uniformly over the entire surface of the soil.

This procedure is entirely satisfactory, according to our present knowledge, where water-soluble types of fertilisers supplying ammonia compounds and potassium compounds are concerned. The ammonia and potash bases are leached into the soil, the penetration being appreciable, and most of them are adsorbed by the soil colloids in a condition readily available to plants.

But if water-soluble phosphatic fertilisers are used chemical fixation of the phosphates occurs in the form of iron and aluminium phosphate to a very high degree, and this is liable to take place in a very shallow surface skin of soil. Once fixed in this form, the phosphates are relatively unavailable to plants. Water-soluble forms of phosphatic manures *e.g.* superphosphate, Nicifos, etc, become completely fixed much more rapidly than the more insoluble types, *e.g.* basic slag, rock phosphates, etc. but for either type if the fertiliser is disseminated through a soil depth of several inches, the general benefit to the root system will be considerably greater than by merely broadcasting the manures, and also, for insoluble forms, the risk of fertiliser losses by erosion will be minimised. Hence it is advised that all phosphatic fertilisers be forked or dug into the top three inches of soil.

Obviously, forking over the whole soil area would be the most efficient procedure, but the cost would be prohibitive, and as a compromise forking in strips is advised. An arbitrary width of

six feet to eight feet has been chosen, as well as the depth of forking, three inches, and in mature areas these strips should run centrally between tree rows. For younger trees, forking of fertilisers should be in the tree rows themselves.

The cost of application, including forking, averages about \$1.75 per acre, with an additional charge for any control of covers which may be necessary.

From evidence available for other crops, unilateral translocation of plant-foods frequently occurs in plants, even manifesting itself in differences between two halves of a single leaf, and where fertilisers for rubber trees are applied in parallel strips, future dressings should if practicable be made in strips running at right-angles to the former ones so as to minimise the possibility of unequal feeding by different parts of the tree.

The presence of covers in areas to be manured may be a disadvantage, so far as the manurial effect is concerned, depending on their type and thickness, owing to resulting loss of fertiliser by "stealing" and to the difficulty of achieving satisfactory forking-in. Any thinning or removal of the covers must however be done with due consideration for the contour of the land and the need for maintaining anti-soil-erosion conditions. Hence, provided there is no danger from soil erosion, covers with dense root systems, *e.g.* grasses, creepers, etc, should be eradicated along the manuring 6ft. or 8ft. strips; bushy or erect types of covers should be thinned out and heavily slashed before applying the fertilisers. On hilly land, the amount of thinning, slashing or eradication must be adjusted according to local conditions, and in very steep areas, it may be necessary to confine manuring to the contour terraces, if they exist, upon which the trees have been planted, rather than thinning out strips between terraces.

For mature rubber trees, although experiments have just been started, no information yet exists regarding the rate and frequency of application of fertilisers nor regarding the time of the year when the application of fertilisers can be expected to have the maximum benefit on the trees. On theoretical grounds it is considered that manuring can be done to the best advantage immediately after wintering, when the new leaves have formed, and during the ensuing period of four to five months, and this is the normal recommendation which is made.

MANURING OF BUDDED TREES OF DIFFERENT CLONES

The possibility of different clones having specific plant-food requirements has been considered during the past year, and one particular aspect of this question has been raised by the habit of abnormal defoliation which has been manifested by certain clones

(e.g. S.R. 9 and P. B. 186). This defoliation may show up as a thin and weak foliage during most of the year or as a complete loss of leaves during a non-wintering period, e.g. October, persisting until after the normal wintering has been completed.

These types of defoliation have been reported in various parts of the country, on different types of soil, and usually on young trees about four or five years old, in which no signs of pathological disease are present. Use has been made of manures, particularly in the form of heavy potash dressings, in attempts to counteract the loss of foliage, but no definite results have been obtained yet. As clones adjacent to the affected ones remain quite normal, the effect may prove to be a clonal characteristic which is in no way related to the "external" nutrition of the plant, and further observations are required on the reaction of the clones in question to manures.

COMPOSTS

The production of "Compost manures" (or artificial cattle-manures) has aroused some interest amongst rubber-planters, probably as a result of the wide publicity given to this form of manure in Europe and in some tropical countries. Whilst there is no doubt that composts can be manufactured in Malaya quite successfully, either directly on the lines of the "Indore" process or by some modified procedure, the successful development of compost-making into a normal rubber-estate practice, of economic and commercial value, will depend upon several factors.

The object of compost-making under Malayan estate conditions is to utilise waste materials (plant residues, domestic refuse, cattle urine and droppings) to form a manure which will be as effective as, but cheaper than ordinary chemical fertilisers.

To manure annually 200 to 300 acres of rubber trees, using a compost, it is estimated that 100 to 150 head of cattle are needed on the estate, and that about one ton of dried plant material would be required per acre manured. Hence the provision of the requisite number of cattle and the quantity of *waste* plant material is likely to be a big problem on the majority of rubber estates. Whilst all types of vegetation can be used—*lalang* grass, small bushes, light *belukar*, etc.—the main source of supplies will have to be swamp areas and waste land, which are very limited in extent, and the cost of cutting and transporting of the material to the composting heaps is likely to be considerable. The utilisation of existing cover-plants under rubber trees on the estate cannot be recommended, on the grounds that the soil from which they are removed will be subject to erosion losses and deterioration from excessive heating, and also there may be

appreciable nitrogen losses from the material during composting, resulting in a net loss of nitrogen to the soil.

When the compost has been made, its chemical composition must be considered before using it, and in relation to the plant-food deficiencies of average Malayan soils, every application of five tons of compost (which is a suitable dressing per acre) will require also an addition of about one-cwt. rock-phosphate. Samples of compost made on rubber estates average about 60 per cent moisture, and on the oven-dry weight contain about 1.3 per cent nitrogen, 0.6 per cent P_2O_5 , and 0.8 per cent K_2O .

The estimated cost of a 5-ton application (including rock-phosphate and extra transport and digging expenses above those required for chemical manures) will be from \$12.00 to \$16.00 per acre, which compares favourably with \$18.00 to \$20.00 per acre for complete chemical fertilisers. Until the estate labour force has become familiar with the working procedure for manufacturing composts, the initial costs are likely to be higher than those stated above. Also, the application of five tons per acre of a bulky organic fertiliser to a perennial crop like rubber will lead to extensive root-disturbance and, possibly, root-damage, and on hilly land there may be the additional risk of serious soil-erosion. These disadvantages can be avoided only by careful and well supervised work, which increases the cost of application.

In other countries the value of composts is largely owing to their provision of a source of humus in soils which are markedly deficient therein, and under conditions where alternative sources of organic matter are not, or are only less economically available. These conditions do not obtain on the average Malayan rubber estate, where the humus-supply of the soil is more easily and economically maintained by other means, *e.g.* cover-plants, which at the same time confer other benefits on the soil not derivable from composts. The value of composts under these conditions must therefore be assessed mainly as a source of plant-food, *not* of humus as well, and if they do not enable plant-foods—primarily nitrogen, phosphates and potash—to be utilised by the rubber trees more effectively or cheaply than when they are applied as inorganic fertilisers, composts are not an economic proposition.

To sum up, compost-making can be done on rubber estates in Malaya, but the advantages in favour of it are not overwhelming, and no strong case can be made out for its extensive adoption in this country. Individual estates may be exceptionally advantageously placed, and in such cases may well give it a trial.

Experiment Station

The main experimental blocks of the Soils Division, in which the effects of manures and covers on young rubber plants are

being studied, were maintained. There is as yet little new information to record. The general manuring at the Experiment Station with a 'complete' fertiliser of high potash-content, which was carried out early in the year, and which will be repeated and extended in 1938, produced some obvious foliage improvements, notably causing the yellowing and bronzing of leaves in certain areas to disappear or become much improved.

Manuring trials were put down in Block 17C in connection with the work on rubber-leaf analysis, and a small replanting experiment was commenced in Block 13.

Further girth-measurements in Block 27 now show that a slight but significant retardation has been produced by creeping and bush legumes and by *belukar* receiving minimum control, in comparison with natural cover-plots where slashing control is maintained.

In connection with experimental work on estates and the recording of yields of rubber from plots, the system of recording yields in Block 6 was changed for the last three months of the year. During this period, the latex from individual tappings was cup-coagulated and after drying at the end of the month, each piece of coagulum was weighed separately. In this way the yield for each tree was separately recorded for each tapping, and the data so obtained are now in the process of examination by the Statistician for the purpose of ascertaining the minimum number of trees and of tappings required to give an accurate measure of the yield for a block of rubber trees. The information which will be obtained obviously will be of considerable value for experiments on estates where only a limited amount of supervision is available: the inaccuracies which are caused through tampering with the latex in its passage from field to factory will be removed; the amount of time and labour specially devoted to recording plot-yields may be considerably reduced, and if necessary the recording can be done entirely by specially-trained Asiatic members of the staff of the Institute.

Experimental Planting of Reserve Jungle Land

(as permitted under the Rubber Regulation Enactment)

The selection of areas for the main types of experiments was completed and they now comprise:—manuring experiments, 29 estates; cover-crop and manuring experiment, 1 estate; methods of opening jungle land (in conjunction with Botanical Division), 7 estates; cover-crop and cultivation experiments (in conjunction with Botanical Division), 3 estates. These experiments occupy nearly 3,000 acres and all except 150 acres were planted by the

end of 1937. The Botanical Division has a large area planted, or in the process of planting, for experimental work on its own subjects and there is a small balance of land available which will be used in 1938 for extending the work already commenced on the above areas.

For the manuring experiments, Institute Conductors have been sent in almost every instance, to supervise the application of fertilisers, and in order to ensure accuracy in this, special tin measures have been provided by the Soils Division. Growth measurements are taken, with few exceptions, by Institute Conductors, heights being recorded at three months' or six months' intervals during the first year, and later, girth measurements.

In several experiments significant responses to phosphatic manures have been obtained in the first six months, and the need for early manuring on certain types of soil, even when planting immediately follows the clearing of virgin jungle, is thus indicated.

A number of experimental areas have suffered considerable damage from rats which have either removed and destroyed seed which have been planted out, or else have nibbled through the stems of young seedlings or basket plants. The amount of damage has varied among different estates, but it has been greatest where felling and planting have been done without burning, the lying timber, etc., giving excellent shelter and concealment to the rodents. Numerous remedies have been tried, *e.g.* rat-traps, guards around the seedlings made of wire, tin or even paper, various types of poisons and repellants, etc., and it is apparent that where no burn or only a light burn is carried out during planting preparations, special care must be taken to give an early check to any possible damage from rats. The cost of counter-measures and of supplying may amount to \$10/- or \$20/- per acre, apart from the general set-back to growth which occurs, and owing to this it may be necessary, in future commercial planting, always to have a light or partial burn.

Laboratory Research Work

SOIL PROFILE STUDIES

Following the establishment of normal laboratory working conditions in May 1937, steady progress was maintained with the analysis of soil-profile samples for the purpose of studying and classifying rubber-estate soils. With the additional laboratory staff engaged in June 1937, the completion of the analysis of the accumulated samples comprising some 300 profiles was estimated to require 12 to 15 months' work.

COMPOSITION OF RUBBER LEAVES

By the end of December the programme of analysis of rubber leaves was completed, over 650 samples having been examined, determinations being made of nitrogen, phosphate, potash, calcium and magnesium in each one. A large number of the samples have been taken from trees in manuring experiments where definite growth or yield responses have been obtained, and the complete set of analyses will be critically examined from the point of view of the value of the analysis of rubber-leaf material in assessing the manurial requirements of rubber trees.

INOCULATION AND MANURING OF LEGUMINOUS COVERS

The value of covers in general to soils on rubber estates is well appreciated, but in Malaya there is normally great difficulty in establishing leguminous cover-plants under mature rubber trees and even when planted in new clearings they have not persisted for very many years. This problem is closely connected with the well-known retardation of growth of young rubber plants which occurs in new plantings or replantings where vigorous leguminous covers are growing, and a study of certain aspects of it was commenced by Mr. Hamilton in 1937. The bacteriological work was done in conjunction with the Pathological Division (Mr. Beeley), who prepared and isolated cultures of root-nodule bacteria taken from leguminous covers which were growing on several rubber estates under different soil conditions. One type of cover has been used, *Centrosema pubescens*, and efficient strains of nitrogen-fixing bacteria have been prepared. Comparisons of the value, in promoting cover-growth, of inoculation of the cover-seeds prior to planting and of different manurial treatments have been made, using sterilised and unsterilised soils in pots in a small pot-culture house which has been erected at the Institute. Field experiments have also been commenced in conjunction with the laboratory work, which includes analysis of the drainage water from the pots, counting of root-nodules, and analysis of the plants after harvesting.

The results which have so far been obtained give the following indications: (I) the great value of phosphate manures to the covers; (II) potash and nitrogen manuring are of much less importance but may be required under certain conditions; (III) no very definite advantage from inoculation has yet emerged; (IV) the elimination of root competition from mature rubber trees is absolutely necessary.

The work is being continued and extended in 1938 when definite results from the field trials are expected.

PHOSPHATE STATUS OF MALAYAN SOILS

The value of phosphate-manuring to young rubber trees, on most Malayan soils is definitely established now, particularly when replanting but also sometimes where virgin jungle soils are concerned, and although laboratory work on this subject was not commenced in 1937 the corresponding field experiments both on virgin soil (6 estates) and in mature rubber areas (5 estates) were started in the latter half of the year. The object of these experiments is to determine the effect of phosphate-manuring on growth and yield of rubber trees on various soil types. Different types of phosphate manures are being used, in the presence and absence of other nutrient elements.

SOIL NITROGEN STUDIES

During 1938, laboratory work which it was not possible to start in 1937, will be commenced on the absorption of basic nitrogen in the soil, on the leaching of nitrogen from the soil and on soil changes under cover crops. A field experiment dealing particularly with the nitrogen-manuring of mature rubber trees was laid out at the end of the year, the object being to ascertain the optimum nitrogen requirements of mature trees, with special regard for the frequency and size of manurial applications and also for the period of the year at which manuring is most beneficial.

LOSS OF AMMONIA FROM FERTILISER MIXTURES

The work under this heading which was done in 1936 was extended, using a greater variety of phosphatic fertilisers and also over a longer period of time. The proportions of the mixtures of ammonium sulphate with the phosphate manures were varied and due allowance was made for differences in moisture-content of the mixtures. The general conclusions previously reached were confirmed, and a detailed account of the experiments is being prepared.

MANURIAL REQUIREMENTS OF RUBBER TREES

In connection with the general aspects of manuring, a detailed study was made of the distribution of the more important chemical elements in the various portions of a rubber tree, and the analyses will be completed and reported upon early in 1938.

Acknowledgment

The very willing and helpful co-operation of managers and estate staffs on all experimental areas which are being developed by the Institute, is very gratefully acknowledged.

Publications

The following article was published in the *Journal* during the year:—

“Manuring Experiments on Young Rubber Trees—R.R.I. Experiment Station, Block 6”

by C. G. Akhurst *J.R.R.I.M.* 8 (1937) 46.

Summary of Rainfall at the Experiment Station

		1932	1933	1934	1935	1936	1937
		inches					
January	...	4.92	6.06	11.01	5.46	4.73	12.45
February	...	8.98	6.69	5.85	3.85	6.45	6.09
March	...	10.51	19.17	13.36	6.69	12.69	7.08
April	...	6.19	16.35	12.01	7.04	7.04	7.36
May	...	8.67	9.41	4.55	5.01	13.57	6.28
June	...	2.40	2.76	6.05	5.74	7.18	1.88
July	...	2.77	4.62	5.62	2.35	0.66	4.74
August	...	12.73	4.65	7.63	11.51	4.01	4.91
September	...	8.31	10.16	9.56	5.15	7.66	9.52
October	...	17.29	6.56	10.00	9.88	11.12	15.66
November	...	11.76	11.40	15.82	12.16	9.34	11.33
December	...	12.74	14.75	3.35	18.12	8.57	10.93
Total	...	107.27	118.58	104.81	92.96	93.02	98.23

C. G. AKHURST

Head of Soils Division

Kuala Lumpur,

8th April, 1938.

ANNUAL REPORT

BOTANICAL DIVISION

During the year under review the work of the Botanical Division has been steadily extended. Additions to the Senior Staff of the Division have made it possible to undertake new investigations and have relieved the pressure of general advisory work which has seriously hampered the progress of research since 1932, though this relief did not come until nearly the end of year.

Staff and Organisation

Two appointments to the Senior Staff of the Division were made during the year. Mr. N. Wright arrived in Malaya on 14th August, 1937 and assumed duty on that date; Mr. E. R. Guest was appointed on the Staff of the Division on 11th November, 1937.

These additions have made it possible to re-orientate the research programme so that each Senior Officer assumes the chief responsibility for one or more clearly defined sections of the general programme of research.

Thus, the Head of the Division continues investigations on vegetative propagation, the study of clones and the selection of improved planting material.

Mr. C. C. T. Sharp will now be able to devote a greater part of his time to genetical work and, with the completion of the tapping experiments on Seventh Mile Estate in June 1938, he will be able to make selection and breeding his principal subjects of research.

Mr. E. R. Guest has taken over much of the work on tapping of seedling and budded trees and towards the end of the year additions to the research programme were made in order to increase the scope of this work, by the initiation of comprehensive series of new experiments on the R.R.I. Experiment Station at Sungei Buloh and on a number of carefully selected areas on Estates.

Dr. E. D. C. Baptist is chiefly concerned with more purely physiological investigations. His principal subject of research will be concerned with problems relating to the nutrition of the rubber tree but additional physiological studies, arising in relation to other branches of the general work of the Division, have also been undertaken. The physiological aspect of stock and scion relationship in *Hevea* will receive special attention.

Mr. N. Wright has worked in close contact with the Head of the Division and from the beginning of 1938 has assumed

responsibility for much of the work entailed in the development and control of new experimental areas on estates.

Mr. K. N. Kaimal has continued his work on the Pilmoor clones and assists the Head of the Division and other officers in anatomical investigations which arise from time to time in the course of their work. Ecological studies in relation to rubber cultivation are also conducted by this officer.

Mr. T. V. Vaidyanathan assists Mr. C. C. T. Sharp in breeding and selection investigations.

The Head of the Division, with the assistance of Mr. N. Wright, has retained the bulk of the general advisory work of the Division. He is further assisted by the senior research officers in dealing with enquiries on subjects with which their own investigations are particularly concerned.

Brief reports on the principal projects of research follow in Sections I to VII; a review of advisory work is given in Section VIII.

I. Vegetative Propagation

(1) METHODS OF PROPAGATION AND PLANTING OF BUDDED TREES

Variations in methods of planting buddings have been the subject of numerous enquiries, and experiments have been commenced to compare various methods of planting, *e.g.* budding in the field, on established seedlings, grown from germinated seed planted "at stake," from basket plants or from "stumps"; budded stumps; and stumped buddings.

In connection with work on the relationship of scion and stock in *Hevea* methods of vegetative propagation of "clonal" stocks are being investigated.

Use of Chemicals to stimulate the formation of Roots on Cuttings

Preliminary experiments have shown that free-rooting is obtained with cuttings 18 inches in length, taken from the basal end of the main stem of seedlings from one to two years old, after treatment with "Hortomone A" (1 in 320) for 24 hours.

Six weeks after treatment all treated cuttings had produced 10 to 16 roots, the longest roots ranging from six to nine inches in length. Four months later the roots had reached a length of three to four feet. These roots grew out straight and vertical and had numerous lateral branches abundantly supplied with feeding-roots which formed a dense network in the top foot of soil.

Cuttings treated with tap water had formed a callus but no roots (one case occurred where a 'control' cutting had formed a root about six inches long at the end of five months).

Cuttings taken from higher up the stem of seedlings and from buddings of the same age as the seedlings have failed to respond to treatment with "Hortomone A" solution at dilutions of 1 in 320 and of 1 in 160 or with the following pure chemicals:—beta-indolyl-acetic acid, alpha-naphthalene-acetic-acid, beta-naphthalene-acetic acid, beta-indolyl-propionic acid, phenyl-propionic acid, phenyl-acetic acid and methyl-beta-indolyl acetate at dilutions of 1 in 20,000, 1 in 40,000, 1 in 100,000.

The cuttings were set out in sheltered beds in the open and the rooting medium was a light sandy soil. The conditions affecting rooting are being investigated.

(2) STOCK-SCION RELATIONSHIPS IN BUDDINGS OF *Hevea*

In previous Annual Reports accounts of investigations designed to study the relationships between stock and scion have been given. There will be little to report on most of these studies until the various experimental areas in which material has been planted reach the tapping stage. The work has been extended during the year by further investigations on clonal seedling families.

Study of Seedling Root Systems

Nine families of clonal seedlings, illegitimate seedlings from clones A.V.R.O.S. 49, 50, 152, 265; B.D. 5, B.D. 10; Tjirandji 1, S.R. 9 and Pilmoor A. 44 were established in the nursery in October 1936. The complete root systems of a number of seedlings of each family have been excavated in detail and scale-drawings made in the field. Some notable differences have been observed in the form and distribution of the root system between the members of the different families.

The information obtained by this 'direct' method will be supplemented by a quantitative determination of root distribution at different depths.

This investigation forms part of the work on stock selection and it is proposed to select three or four families of seedlings representing the widest range in form of root system and to bud these with scions of three clones, *e.g.* B.D. 5, P.B. 86 and Tjirandji 1, which are representative of the most divergent scion types.

Clonal Seedlings as Stocks for Buddings

Four families of clonal seedlings were planted in December 1931 and half of the trees of each family were budded in December 1932 with P.B. 186. The girth measurements of the budded and unbudded trees are tabulated below.

TABLE I. *Growth of Clonal Seedlings and of Buddings made on Clonal Seedling Stocks*

Illegitimate Seedling Family of Clone:—	Unbudded Trees			Budded Trees			
	No. of Trees	Girth at 20 inches	Devia- tion from mean	No. of Trees	Girth at 40 inches	Devia- tion from mean	Per- centage tappa- ble trees 1/1/38
Pilmoor A, 44	96	25.7	— 1.3	72	17.2	— 0.2	58
„ B, 50	81	28.0	+ 1.0	88	17.8	+ 0.4	63
„ B, 58	131	28.0	+ 1.0	115	17.9	+ 0.5	67
M.A.P. Clones	102	26.4	— 0.6	95	16.7	— 0.7	45
Mean		27.0			17.4		

There is clearly a tendency for the strongest-growing families of seedlings to produce, when used as stocks, the strongest growth of the scions. The difference in the growth of the scions is in itself small though its effect from the practical standpoint is more marked if the proportion of tappable trees, five years after budding, is considered.

The apparent discrepancy of the relation of the girths of the budded and unbudded trees, as between the A. 44 and M.A.P. families, can be accounted for by the greater tendency of the A. 44 seedlings to break in the wind. By the end of 1937 fifteen of these seedlings were broken in the wind compared with only one tree of the M.A.P. family. In 1933, before any storm damage had occurred, the girth of the trees which eventually broke was 17 per cent higher than the mean of the whole family. Storm-damage in the A. 44-family is apparently selective in its action and the strongest-growing trees show the greatest tendency to break. This selective action has resulted in a lowering of the mean girth of the unbudded seedlings of A. 44 but has not had any ill-effect on their value as stocks.

(3) GROWTH AND YIELD OF BUDDED TREES

Regular tapping of proved clones in Blocks 5, 17 (A) and 21 has been continued and tapping in Block 17 D (South) commenced on 1st January 1937.

The principal data are summarised in Table II.

Experimental Block No.	Acreage	Description of Block	Clone	Tappable Trees Percentage		Yield lb. per tree per year		Wind Damage Percentage	Brown Bast Percentage
				1936	1937	1936	1937		
5	40	Planted with budded stumps in November 1929 in plots of single clones. 108 trees per acre. Randomised block experiment with 4 replications. Age at commencement of tapping in Jan'y., 1936—6 years	A.V.R.O.S. 152	59	80	3.7	4.8	0.6	0.5
			A.V.R.O.S. 49	63	84	4.6	6.5	—	—
			P.B. 23	57	83	4.9	7.7	—	—
			P.B. 186	74	88	4.9	8.1	0.6	—
			B.D. 5	18	75	4.1	5.3	—	—
17 A	10	Planted October 1929. Budded December 1930. Interplanted April 1930 with seedlings. 180 trees per acre in equal proportions of buddings and seedlings. Age at commencement of tapping, Jan'y., 1936: Buddings 5 years. Seedlings 5½ years.	Tj. 1	51	63	6.7	9.3	5.4	—
			Tj. 16	16	39	6.4	7.4	—	—
			A.V.R.O.S. 183	9	29	6.4	7.7	—	—
			A.V.R.O.S. 185	18	48	8.0	8.1	0.7	—
			Glenshiel 1	26	44	6.4	7.6	—	—
17 D South	8	Planted October 1929. Budded April 1931. Interplanted April 1930 with seedlings. 180 trees per acre in equal proportions of buddings and seedlings. Age at commencement of tapping, Jan'y., 1937: Buddings 5½ years. Seedlings 6½ years.	A.V.R.O.S. 50	10	34	3.1	3.8	—	1.3
			Seedlings (Unselected)	79	100	3.2	4.9	0.6	—
			Tj. 1	—	45	—	7.2	1.4	—
			Tj. 16	—	17	—	6.5	—	—
			Rub. 393	—	24	—	2.9	—	—
21	25	Planted December 1929. Budded October 1931. 90 trees per acre. Age at commencement of tapping, Jan'y., 1937: 4½ years.	Sab. 24	—	22	—	4.0	—	—
			Glenshiel 1	—	21	—	6.1	—	3.2
			A.V.R.O.S. 50	—	23	—	3.7	—	0.3
			Seedlings (Unselected)	—	70	—	3.6	0.2	—
			Tj. 16	10	35	6.3	8.3	0.6	0.9
			A.V.R.O.S. 71	47	59	3.6	6.1	4.0	1.0
			B.D. 10	40	55	3.5	6.5	3.4	1.7
			S.R. 9	9	25	2.9	4.8	0.3	—
			A.V.R.O.S. 256	21	43	2.3	3.0	—	2.1
			Cl. 88	40	59	4.5	6.5	1.2	—
			A.V.R.O.S. 50	22	53	2.9	4.8	0.3	—

Heavy supplying took place in Block 5 during 1930 and 1931 and the percentage of tappable trees is estimated from only those trees of the original planting which still survive.

Only a small amount of supplying was necessary in Blocks 17 and 21 and the proportion of tappable trees is estimated from all trees and not only from the original planting.

A further thinning-out to 125 trees to the acre took place in Block 17 A. Weak or stunted budded trees were removed and many seedling trees were cut out. The latter were selected on the yields obtained during the first six months and the present stand consists of 86 buddings and 39 seedlings per acre. The heavier thinning-out of the seedling trees would tend to raise their mean yield in comparison with that of the buddings.

The yields of the clones tested confirm those of the original budded trees and call for no particular comment. The highest-yielders on the poor soil of the Experiment Station are Tjirandji 1, B. 84, P.B. 186, Avros 185 and A. 44. Owing to their poor bark characters the last two should not be used for commercial planting.

In Block 5, two of the five trees of Tjirandji 1 affected with brown bast have recovered and are again in tapping.

TABLE III. *Density of Planting. Summary of Growth and Yield Records*

Clone Avros 50. Planted as Budded Stumps in November, 1930
Lay-out:—Latin Square, six replications, Area 40 acres

No of Trees per acre	Mean Girth in inches at end of each year of age:—						Yield Data 1937. Age 6—7 years		
	2	3	4	5	6	7	Percentage Trees Tapped	Yield in pounds per tree	Yield in pounds per acre
48	4.8	8.0	1.21	16.4	19.3	23.0	75	5.3	190
108	5.1	8.3	12.1	16.3	18.7	21.7	64	4.8	336
125	5.1	8.2	12.1	15.5	18.1	21.1	61	4.4	334
222	4.9	7.8	11.5	14.8	17.1	19.7	51	3.6	409
302	5.1	8.2	11.7	14.2	15.9	17.7	39	3.2	375
435	5.2	8.1	11.1	13.2	14.7	16.1	20	2.9	256

The growth and yield records taken in the experiment on density of planting with Clone Avros 50 (R.R.I.E.S. Block 14 C & D) are set out in Table III above. The poorer growth of the densely-planted plots after the third year from planting is

reflected in the smaller proportion of tappable trees. The highest yield is obtained from the plots with a stand of 222 trees per acre.

The differences in the mean girths of the trees at the different densities of planting are becoming progressively larger each year.

II. Tapping Investigations

The circumstances limiting the development of our work on tapping problems were outlined in the Annual Report for 1936 and it is therefore gratifying to report that towards the end of 1937 it was possible to make provision for a comprehensive series of new experiments on estates. Mr. Sharp's work during the past five years on Seventh Mile Estate has opened up a number of extremely interesting and important problems and affords a sound basis for planning further investigations. At the time of publication of this report negotiations will have been completed with a number of estates to set up a new series of tapping experiments. The principal object of these experiments will be to investigate further the economic value of periodic tapping systems on mature rubber areas of different yielding capacities on a wide range of soils. A similar new series of experiments on the tapping of budded trees, to extend the scope of those which have already been in progress on large-scale monoclonal plantings, has also been commenced. These large-scale experiments on estates will be of the greatest value in supplementing the results of more complex and critical work which can only be conducted satisfactorily on a relatively small scale on the R.R.I. Experiment Station.

In collaboration with the Soils Division, the combined influence on yield of manuring and choice of tapping systems will be investigated.

(1) TAPPING EXPERIMENTS ON MATURE SEEDLING TREES

Investigation of Economic Tapping Systems; Experiment on Seventh Mile Estate

The yield of the various tapping systems compared in this experiment, for the first half of the fifth (and last) year, are set out in Table IV.

The yields of the different tapping systems remain at almost exactly the same relative levels as in the corresponding period for 1936. The experiment will be concluded at the end of May 1938 and it is proposed to prepare a full account of the work for separate publication as a research bulletin. No further comment is therefore made in the present report.

TABLE IV. *Seventh Mile Estate Tapping Experiment*

*Yield in pounds per Acre of First-Grade Rubber
Scrap and Total Dry Rubber, June 1937 to November 1937*

Tapping Systems	Period		Yield of First-Grade Rubber		Yield of Scrap Rubber		Total Yield	
	Tap- ping Mths.	Rest Mths.	Lb.	Per cent of Control	Lb.	Per cent of First- Grade	Lb.	Per cent of Control
A.B.C. -	6	3	312.0	83.7	24.7	7.9	336.7	83.2
A.B.C. -	10	5	299.5	80.4	23.1	7.7	322.6	79.8
A.B.C. -	14	7	291.1	78.1	22.4	7.7	313.5	77.5
Sunderland ⁽¹⁾ -	3	3	261.1	70.1	26.1	10.0	287.2	71.0
Sunderland -	5	5	274.4	73.6	28.4	10.3	302.8	74.9
Sunderland -	7	7	264.3	70.9	27.4	10.4	291.7	72.1
Double-Four ⁽²⁾ -	12	4	279.0	74.9	29.8	10.7	308.8	76.3
A.D. (Control) -	Continuous		372.6	100.0	31.9	8.6	404.5	100.0

- (1) Sunderland Systems:—Two cuts on opposite halves of the circumference of the tree tapped every third day with resting periods equal to the tapping periods.
- (2) Double-Four:—In this experiment the system is double-four A.B.C.D. Two cuts on opposite sides of the tree, as in the Sunderland System, tapped every fourth day for 12 months. Trees rested for four months. (For the first 28 months of the experiment no rest periods were included).

Tapping on the Full Circumference of the Tree

"Complete Spiral" (R.R.I. Experiment Station—Block 6)

The small-scale experiment to compare different methods of tapping on the full circumference of the trees has been continued and the results are tabulated below.

Yields on systems 1 and 2 appear to have fallen off in relation to the control; this can probably be accounted for by the fact that half of the control trees were tapped at the base of the tapping panel at which point the yield reached its maximum for the panel. That this drop in yield did not occur in System 3 (full spiral) emphasises the satisfactory results so far obtained with the full-spiral cut. No ill-effects on the trees have yet been observed in the two-cut and full-spiral groups. Bark renewal on the trees in these groups appears to be superior to that in the control group during the first two years of the experiment.

TABLE V. *Comparison of "Two-cut" and "Full-Spiral" Tapping Systems*

Group No.	Position of Tapping Cuts	Frequency of Tapping	Yield as Percentage of Control (4 below)	
			Aug. 1935 to Dec. 1936	Jan.—Dec. 1937
1	Two left-to-right spiral cuts on half-circumference. Upper cut opened at height of 40 inches; Lower cut opened at height of 20 inches on opposite panel.	Alternate-daily 3 months tapping 3 months rest	92	81
2	As in 1 above.	Every 4th day "Double-four" No rest	112	101
3	Left-to-right spiral cut on full circumference. Opened at height of 30 inches.	Every 4th day No rest	120	119
4	Single left-to-right spiral cut on half-circumference. Even-numbered trees opened at 40 inches; Odd-numbered trees opened at 20 inches. (Control).	Alternate-daily No rest	100	100

Note:—All tapping heights are measured from ground level to the lowest point of the tapping cut. Bark consumption is controlled so that the total bark consumption, measured in vertical units, is the same for all groups.

Influence of Rate of Bark Consumption on Yield

Bark Consumption Experiment No. 2 (R.R.I.E.S. Block 13B)*

Experiment No. 1 was set up in 1934 to compare the yields obtained from seedling trees with rates of bark consumption of $\frac{3}{4}$ inch, 1 inch and $1\frac{1}{4}$ inches per month. The yields obtained were in the proportions 100: 98.5: 99.3 respectively.

Since it was thought that this negative result might have been due to the exceptional skill of the Chinese tapper employed, new panels were opened on the opposite sides of the trees and the

* See Annual Report 1935, p. 78.

experiment was repeated, but a Tamil tapper of average skill was employed in the place of the Chinese tapper.

The second experiment was completed in January 1937 and the yields with rates of bark consumption of $\frac{3}{4}$ inch, 1 inch and $1\frac{1}{4}$ inches per month were in the proportion of 100: 98.2: 94.5 respectively. In neither experiment are the differences significant.

At the time that this experiment was started only a small proportion of the Experiment Station was in tapping and the supervision was intensive. In consequence of this, the skill of the tapper soon reached a high standard.

The absence of any increase in yield with an increase in the rate of bark consumption was unexpected, but the results are interesting in that they indicate that the maximum yield can be obtained with a bark consumption of $\frac{3}{4}$ inch per month provided that the standard of tapping is sufficiently good.

In both experiments the trees were tapped alternate-daily on a half-circumference cut.

Drastic Tapping Experiment

An experiment to compare three drastic tapping systems was set up on an estate on the coastal belt in south Perak, on an area of heavy clay land. It was desired to find out what crop could be obtained from old rubber, over 30 years of age, during the last six months of its existence prior to its being cut out and the land replanted. The systems compared were:—

I. Two half-circumference cuts on opposite sides of the tree tapped daily. The cuts were on renewed bark as near the base of the tree as possible. Task size:—150 trees.

II. Four, half-circumference cuts, two on opposite sides of the tree, on virgin bark above the tapping panels, and two on opposite sides of the tree on renewed bark as near the base of the tree as possible. Daily tapping, the two upper cuts being tapped on one day and the two lower cuts on the next day. Task size 140 trees. Ladders were used for tapping the upper cuts.

III. Similar to I, but the cuts were opened on virgin bark above the tapping panels. Task size 130 trees. Ladder tapping.

The results are given in Table VI.

Very large increases in yield were obtained with all three systems. It was clear that in this experiment the yield from the renewed bark is greatly superior to that of the virgin bark above the tapping cuts. This may be found to be true of rubber trees of this type on similar coast land estates.

The small excess yield of System II over System I would not compensate for the higher tapping costs. It appears however from the yield curves that if the experiment had been continued for

a longer period the excess would have been greater, as the yields for the last three months of tapping were respectively in the proportion of 100: 119: 90 for the three different systems.

TABLE VI. *Drastic Tapping Experiment on Old Rubber Trees*

Tapping System	Mean Yield lb. per acre on A.D. Tapping during the periods July—December in 1934 and in 1935	Yield lb. per acre July—December 1937	Yield July—Dec. 1937 as percentage of yield for corresponding periods in 1934 and 1935
I	162	488	301
II	162	501	309
III	162	297	183

(2) TAPPING EXPERIMENTS ON BUDDED TREES

Tapping of Mature Budded Trees

The tapping of the original series of buddings of the Pilmoor clones has been continued and the principal data from the best two clones are summarised in Table VII.

TABLE VII. *Tapping of Mature Budded Trees. Pilmoor Clones*

Clone:—	B. 84				D. 65			
Year ...	1934	1935	1936	1937	1934	1935	1936	1937
Year of Age ...	10th	11th	12th	13th	10th	11th	12th	13th
Mean girth in inches at 40 inches from union ...	36.0	37.6	38.9	40.2	36.4	37.3	39.2	39.8
Mean yield in pounds per tree per year ...	18.5	19.2	21.5	17.7	26.0	23.2	23.0	17.6
Mean dry-rubber-content of latex per cent ...	38.0	38.2	37.8	39.6	32.8	31.0	36.4	34.3

On 1st January 1937 a new tapping panel was opened at a height of 40 inches. The new cuts on half-circumference left-to-right spiral, were opened in virgin bark about four inches above the renewed bark of a previous tapping panel which was first

opened in April 1929. During the first half of 1937 the new tapping cuts were therefore gradually approaching the junction between virgin and renewed bark nine years of age. Yields during January were excellent; during the wintering season normal decline occurred and recovery in yield did not become apparent until October or November. There are two reasons which may account for this; first, the period May to August 1937 was extremely dry and yields over the whole district suffered in consequence; second, the decline in yield frequently observed as new cuts approach junctions of bark of different ages, may have occurred in the present instance.

With regard to the influence of weather conditions the data given below are interesting.

Rainfall on the Clone-Testing Area on Pilmoor Estate for the Period 1932—1937

Year	Total Rainfall for the period May to August (4 months following recovery from wintering)	Total Rainfall for the Year
1932	37.56 inches	139.41 inches
1933	36.62 "	121.20 "
1934	26.50 "	106.74 "
1935	23.62 "	104.75 "
1936	20.25 "	98.11 "
1937	13.44 "	110.93 "

From the above table it will be seen that although the total rainfall for 1937 was greater than that for 1936 the drought during the period May to August 1937 was unusually severe. Secondary wintering was apparent during this period and was particularly severe in clone D.65. With the advent of rain in late September all trees developed luxuriant new foliage. The effect of this vigorous new growth was to depress yield further for a short time.

With regard to the effect of the change in position of the tapping cut from virgin to renewed bark, this forms the subject of a detailed investigation to be reported later. For the present, it can be stated that the decline in yield observed is not accounted for by inferiority in the quality of the renewed bark. The yields expressed as pounds per tree per annum, for January and February 1937, during which tapping has been entirely on renewed bark, have been for B 84, 20 pounds per tree and for D 65, 21

pounds, both clones showing a marked improvement on their 1937 performance.

Influence of Tapping Height on Yield of Budded Trees

The experiment in progress on Block 5, R.R.I. Experiment Station, to compare the yields of budded trees of nine clones when tapping is commenced at heights of 20 inches and 40 inches from the union was continued. The rate of bark consumption in this experiment has been approximately seven inches per annum so that it has been possible to continue the experiment for three years without changing the tapping panels. The results for the first three years of the experiment are given in Table VIII.

TABLE VIII. *Comparison of Yields of Budded Trees Tapped at Different Heights*

Clone	No. of Trees Tapped		1ST YEAR :— Age 5 to 6 years			2ND YEAR :— Age 6 to 7 years			3RD YEAR :— Age 7 to 8 years		
			Yield in pounds per tree at heights		Per-cent age	Yield in pounds per tree at heights		Per-cent age	Yield in pounds per tree at heights		Per-cent age
	(a) at 20 ins.	(b) at 40 ins.	(a) 20 to 13 ins.	(b) 40 to 33 ins.		(a) 13 to 6 ins.	(b) 33 to 26 ins.		(a) 6 ins. to union and stock	(b) 26 to 19 ins.	
A.V.R.O.S. 152	27	23	3.5	2.8	80	4.2	4.8	114	5.0	5.0	100
A.V.R.O.S. 49	24	28	4.0	3.5	88	5.7	4.8	84	7.1	6.4	90
P.B. 23	24	22	5.4	4.5	82	7.0	6.0	86	9.0	7.8	87
P.B. 186	27	28	5.2	4.5	85	7.2	6.3	88	8.9	8.1	91
B.D. 5	23	20	3.4	2.8	83	4.1	3.9	95	6.2	5.7	92
Tjir. 1	27	28	6.1	6.2	102	8.8	9.0	102	12.0	12.7	106
Pil. A. 44	21	30	7.2	6.3	87	6.5	7.5	116	7.4	8.3	112
Pil. B. 84	25	26	4.5	4.8	106	7.4	7.0	93	8.8	10.0	113
A.V.R.O.S. 50	27	27	3.1	3.0	97	5.9	5.2	88	7.2	7.0	97
Mean (all clones)	—	—	4.7	4.3	91	6.3	6.1	97	8.0	7.9	99
*Seedlings	91	87	4.1	2.2	54	5.6	3.8	68	9.2	6.9	75

* Seedlings :—These are one year older than the buddings and are growing in Block 6 under conditions very similar to those in Block 5.

During the last two to three months of the third tapping year the tapping cuts on most of the trees opened at the initial

height of 20 inches from the union had crossed the union and were partly in stock bark below the union. There were no appreciable changes in the trends of the yield curves for different clones and no other ill-effects of tapping over the union were observed.

The data summarised in Table VIII show that over the whole period the total crops harvested from buddings opened for tapping at 20 inches or at 40 inches are in the ratio of 100 to 96.3. It is interesting that in the highest-yielding clones, namely Tjirandji 1 and Pilmoor B 84, the total yields over the first three years have been slightly greater from trees tapped on the higher panel, the respective ratios being: for Tjirandji 1, 103.7 per cent; and for B. 84, 105.3 per cent.

Influence of the Direction of the Tapping Cut on the Yield of Budded Trees

The fifth year of this experiment on Clone B. 95 has been completed and the results are tabulated below.

TABLE IX. *Influence of Direction of the Tapping Cut on Yield of Buddings of Clone Pilmoor B.95*

Year	Height of Tapping Cut in January	RELATIVE YIELDS OF :		Difference
		Left-to-right cut	Right-to-left cut	
1933	40	100	74.6	25.4
1934	30	100	82.5	17.5
1935	20	100	92.0	8.0
1936	10	100	95.5	4.5
1937	40	100	75.6	24.5

The difference in yield decreases with the lowering of the height of the tapping cut. In 1937 when the tapping cut was restored to the 1933 level the difference in relative yield returned to a similar value to that obtained in the first year.

"Double-Cut" Tapping on Budded Trees

The preliminary experiment on a moderate-yielding clone, Pilmoor B. 95, has completed its fifth year. Two half-circumference cuts were opened at 20 and 40 inches from the union and were tapped alternate-daily for periods of three months with resting periods of three months.

In March 1937 the lower cut reached the union and a new cut was opened at a height of 40 inches from the union, and 20 inches above the original cut which was opened in March 1933 at 20 inches above the union.

Yields, expressed as percentages of those of comparable groups of trees tapped at heights of 20 inches and 40 inches on a normal, alternate-day system on single cuts, have been:—

1st year	2nd year	3rd year	4th year	5th year
113	120	151	112	102

This experiment has been repeated on nine high-yielding clones on the Experiment Station. During the period May 1935 to April 1937 the trees were tapped on the same system as in the preliminary experiment on Clone Pilmoor B. 95. In May and June 1937 the trees were rested and in July tapping was resumed on both cuts every fourth day without periods of rest. In December 1937 the tapping cuts had reached levels of 29 inches and 9 inches from the union.

TABLE X. *Yields from "Double Cuts" as Percentage of Yields from "Single Cuts"*

CLONE	Trees tapped alternate-daily on 2 cuts opened at 40 inches and 20 inches on opposite sides. 3 months tapping 3 months rest.		The same trees tapped on 2 cuts every fourth day without rest
	May 1935 to April 1936	May 1936 to April 1937	July to December 1937
A.V.R.O.S. 152	103	107	166
A.V.R.O.S. 49	99	79	127
P.B. 23	86	80	132
P.B. 186	82	84	124
B.D. 5	77	63	122
Tjirandji 1	90	77	103
Pilmoor A 44	81	88	115
Pilmoor B 84	91	95	127
A.V.R.O.S. 50	97	82	128
Mean of all clones	90	84	127

The data summarised in Table X illustrate the striking response in yield which has followed the change in frequency of tapping and elimination of the rest periods. The "double-four" system, which is the same as the system used on seedling trees in experiments reported earlier in this section, has given excellent results on buddings. This system should not be confused with the "full-spiral" system; although the tree is actually tapped on the whole circumference the cut is divided into two equal portions, one part being at a higher level 20 inches above the lower section.

The incidence of tapping-panel diseases has been no greater with double-cut systems than with the normal, single-cut systems and bark renewal on trees tapped on two cuts appears to be superior to that on trees tapped on half-circumference.

Comparison of Yields of Budded Trees tapped on the normal system A.D. on half-circumference, on the A.B.C. 6/3 system and on the third-daily system.

The tapping experiments set up in collaboration with estates on monoclonal plantings of a number of proved clones have been continued. Each experiment occupies 18 tasks of about 300 trees, or approximately 60 acres. The three treatments compared are the normal system of alternate-daily tapping, the A.B.C. system of alternate-daily tapping for six months followed by three months rest, and the third-daily system. The length of cut on all three systems is a half-circumference; tapping was commenced at a height of 40 inches from the union with a left-to-right spiral cut.

The oldest experiment of the series, on clone Prang Besar 25, has now been in progress for over four years. The other experiments, on clones A.V.R.O.S. 49, A.V.R.O.S. 50, A.V.R.O.S. 152 and Sungei Reko 9, have been in progress for shorter periods. A further series of experiments, on monoclonal plantings of clones B.D. 5, Tj. 1 and others, is being laid down in the near future. The principal results of the first series of experiments are summarised below.

The actual yields of the different clones cannot validly be compared as the experiments are set up in different localities under different conditions. The chief point of interest in the figures is that reduction in the number of tapping days is reflected in an almost proportional loss in crop. The progressive improvement in the percentage yield of the lighter systems in the first experiment on clone P.B. 25 may be mainly accounted for by the approach of the tapping cuts to the union on the A.D. system. At the end of the fourth year these cuts changed over to the second panel at 40 inches. The yield of the A.D. plots since the turn-over has continued at a much higher level than before—a

total of 527 lb. per acre for the first four months only, whilst the percentage yield on the A.B.C. and third-daily systems has dropped to 51 and 47 respectively. The cuts on the third-daily system are now approaching the union and will shortly be changed over to the second panel.

The results to date indicate that for young buddings of these five clones the normal system of alternate-daily tapping on a half-circumference without rest is not too severe a system. Girth measurements taken towards the end of the year showed no significant differences between the means of the three treatments in any of the experiments. Bark measurements are now being made.

III. Selection and Breeding

NEW CLONES FROM ESTATE MOTHER-TREES AND CLONE COLLECTION.

During the years 1931 to 1933, 235 new clones derived from high-yielding trees selected on estates were established in plots of 20 trees in Block 15 on the R.R.I. Experiment Station. No mother-tree was selected unless its yield was at least five times that of the average tree in the tapping task in which it was situated. One hundred of these clones were brought into tapping in January 1937 and a further 23 clones came into tapping in July 1937.

In the northern end of this block a collection of 55 clones was planted in 1931 and 1932. This consists of clones which had been discarded by 1931 and of younger clones which were unproved at the time of budding.

The yields of the highest-yielding clones derived from estate mother-trees and from the clone collection are tabulated below.

Because of its poor early yields the control clone Avros 50 is now regarded as a second-class clone. (See Table II). Nevertheless, the yields of the best of the new clones are sufficiently in excess of that of Avros 50 to be comparable, during the first year of tapping, with the best of the proved clones.

The highest-yielding clones from the clone collection yield more than most of the new clones from estate mother-trees. With the exception of clone Prang Besar 86 and Lunderston N the former clones are known to possess one or more undesirable characters in consequence of which they are no longer recommended for commercial use. It should be noted that these clones, although no longer recommended for planting are capable of very good yields.

BREEDING INVESTIGATIONS

Breeding work was discontinued in 1931 and was not resumed until 1937. During 1937, 5,294 hand-pollinations were made from

TABLE XII. *Yield Records of the most promising Clones in the Clone Collection and Estate Clones Trial*

Clones from Estate Mother-Trees		Clones from the Clone Collection	
Clone	Yield in pounds per tree in 1937	Clone	Yield in pounds per tree in 1937
R.R.I. 24	6.5	Avros 163	5.3
" 103	7.0	" 150	6.1
" 137	6.4	B.D. 2	5.0
" 138	5.9	P.E. 26	7.1
" 139	6.3	Lunderston N	7.4
" 140	6.3	P.B. 155	7.1
" 142	6.8	P.B. 123	9.1
" 147	7.7	P.B. 31	6.1
" 162	6.3	P.B. 86	6.2
" 163	6.5	R.A. 22	9.2
Avros 50	4.0	Avros 50	3.1

which 346 fruits were obtained (6.5 per cent successes). From these fruits 1,004 seedlings have been raised and these will be planted in 1938, together with buddings made from them, in a new selection block on the Experiment Station. The parents used in these crosses were Pilmoor A. 44, B. 84, B. 58, Prang Besar 24, 49, 86, 186; Tjirandji 1; Bodjong Datar 5; Glenshiel 1; Avros 33 and 157.

Owing to the very wet wintering season the flowering period was exceptionally long. This exaggerated the differences in flowering time of the clones used as parents, and the full programme of crosses could not be completed because insufficient flowers of both parents of a cross were available at the same time.

The full summary of the year's pollination work is given in Table XIII.

There is evidently a very big difference in the fertility of different crosses. In the cross Tj. 1 $\times$ B.D. 5 and its reciprocal, only five fruits were harvested as a result of 317 crosses, whereas in the cross Tj. 1 $\times$ P.B. 86 and its reciprocal, 34 fruits were obtained from 358 crosses and in Tj. 1 $\times$ P.B. 24 and its reciprocal 15 fruits out of 149 were obtained.

TABLE XIII. *Summary of Crosses made during 1937*

Cross	No. of Pollin- ations made	No. of Fruits harvest- ed	Per- centage of success	No. of Seeds planted	No. of Seeds germinat- ed	Percent- age of germin- ation
B.D. 5 x B. 84	119	1	0.8	3	3	100
B. 84 x B.D. 5	167	16	9.6	49	48	97
P.B. 86 x B. 84	212	16	7.5	48	45	93
B. 84 x P.B. 86	18	3	16.7	9	9	100
P.B. 49 x B. 84	167	18	10.8	56	55	98
B. 84 x P.B. 49	8	—	—	—	—	—
Av. 33 x B. 84	94	—	—	—	—	—
B. 84 x Av. 33	29	3	10.3	9	9	100
P.B. 24 x B. 84	163	17	10.4	50	45	90
B. 84 x Tj. 1	66	3	4.5	11	10	91
Tj. 1 x B. 84	64	—	—	—	—	—
B. 84 x Av. 157	81	6	7.4	18	18	100
Av. 157 x B. 84	75	3	4.0	9	9	100
B. 84 x P.B. 186	58	5	8.6	15	15	100
P.B. 186 x B. 84	83	1	1.2	3	3	100
B. 84 x G. 1	53	2	3.8	6	6	100
G. 1 x B. 84	150	8	5.3	24	22	92
Av. 157 x B.D. 5	132	8	6.1	24	23	96
B.D. 5 x Av. 157	132	1	0.8	3	3	100
Av. 157 x P.B. 86	105	8	7.6	25	25	100
P.B. 86 x Av. 157	237	21	8.9	65	58	89
G. 1 x Av. 157	37	12	32.4	36	36	100
P.B. 24 x Av. 157	99	10	10.0	27	24	89
Av. 157 x P.B. 49	132	3	2.2	9	9	100
P.B. 49 x Av. 157	130	23	17.7	72	70	97
Av. 33 x Av. 157	54	2	3.7	6	3	50
A. 44 x Av. 157	158	3	1.9	9	9	100
Tj. 1 x Av. 157	49	1	2.9	3	3	100
Av. 157 x Tj. 1	148	6	4.1	18	18	100
Tj. 1 x P.B. 186	276	16	5.8	52	50	96
P.B. 186 x Tj. 1	63	—	—	—	—	—
Tj. 1 x P.B. 86	134	8	6.1	25	25	100
P.B. 86 x Tj. 1	224	26	12.0	78	75	96
Tj. 1 x G. 1	149	11	7.4	36	36	100
G. 1 x Tj. 1	131	4	3.0	12	10	83
Tj. 1 x P.B. 24	34	2	6.0	6	6	100
P.B. 24 x Tj. 1	115	13	11.2	38	32	84
Tj. 1 x P.B. 49	82	8	9.8	27	25	93
P.B. 49 x Tj. 1	162	10	6.2	31	30	98
Tj. 1 x B.D. 5	160	4	2.5	13	10	76
B.D. 5 x Tj. 1	157	1	0.6	3	2	66
Av. 33 x Tj. 1	101	2	2.0	6	6	100
Tj. 1 x Av. 33	201	15	7.5	53	50	94
Tj. 1 x B. 58	155	9	5.8	29	25	86
B. 58 x Tj. 1	130	17	13.1	49	44	89
	5,294	346	6.5	1,065	1,004	94.3

The direction in which the cross was made also affected the number of successes. At the beginning and end of the flowering season the female flowers of B. 84 were very fertile, but during the middle of the flowering season, when the trees were carrying a large number of flowers, the female flowers nearly all aborted before ripening and could not be used. This did not affect the pollen which remained fully fertile throughout the flowering season.

The flowers of Avros 33 were affected by a mildew and in consequence of this the 94 crosses of Avros 33 $\times$ B. 84 all failed. It was possible by careful selection to obtain a sufficient number of healthy male flowers and the reciprocal cross showed 10 per cent successes. Altogether, the 249 crosses with Avros 33 as the female parent produced four fruits (1.6 per cent) whereas the 230 crosses with that clone as the pollen parent produced 18 fruits. (7.8 per cent).

P.B. 186 also showed a very marked difference in fertility according to the direction in which the cross was made.

The cross Tj. 1 $\times$ B.D. 5 and its reciprocal, which showed such poor successes also gave very poor germination results.

LEGITIMATE SEEDLING FAMILIES OBTAINED BY HAND-POLLINATION

Tapping of the seedling families raised by hand-pollination during the years 1928 to 1931 has been continued.

The yields of the different families do not appear to be affected by the direction in which the cross was made, and therefore, in Table XIV, the yield of each family of crosses has been combined with that of its reciprocal.

In the 1928 series new tapping cuts were opened in July on the opposite panel at 30 inches from the ground. Nevertheless, these families have shown an average increase in yield of 27 per cent compared with that of the previous year.

The cross B. 84 and A. 44 still shows the best yields but there have been 6 per cent of cases of brown bast in the three series combined.

In the 1929 series the tapping cut reached ground level in December and a new cut at 30 inches was opened in January 1938. The increase of 50 per cent in the average yield of all families must be attributed in part to the fact that the tapping cut was throughout the year on the highest-yielding part of the tree. The mean yield is still slightly below that of Tjirandji 1, the highest-yielding clone in Block 5, planted at the same time.

TABLE XIV. *Yields of Legitimate Seedling Families in 1937*

Parents	1928 Series		1929 Series		1930 Series		1931 Series	
	Age on 1.1.37 7 years. 8 months		Age on 1.1.37 6 years 9 months to 7 " 3 "		Age on 1.1.37 5 years 9 months to 6 " 3 "		Age on 1.1.37 5 years 3 months	
	No. of Trees	Mean Yield lb. per tree	No. of Trees	Mean Yield lb. per tree	No. of Trees	Mean Yield lb. per tree	No. of Trees	Mean Yield lb. per tree
A8 & A44	7	8.9						
A8 & B58	21	9.2						
A44 & B58	13	11.7	60	10.2				
A44 & D61	78	11.7	128	9.0				
A44 & B16	34	14.2	94	10.1				
A44 & B84	8	16.1	70	11.8	85	9.3		
B58 & D61	8	7.8					103	5.6
B58 & B16	12	11.3	5	14.3				
D61 & B16	5	8.2	10	5.6			30	3.9
A44 & B50			19	7.9				
D65 & A44			3	5.4	20	4.9		
B50 & B58			22	7.6				
B58 & B84			12	10.9	21	7.7	3	9.1
B84 & D61			44	9.7				
B84 & B16			35	10.6				
D65 & B16			7	7.4	1	2.6		
A44 & B65					15	5.3		
D65 & B84					43	7.0		
B50 & B84					16	8.3		
B58 & D65					10	4.1		
B58 & B65					2	5.9		
C72 & B84			5	14.1				
B58 & C72			3	15.1				
B90 & B16					5	3.4		
B50 & E95			3	6.7				
B95 & A44								
A44 & Lun N	9	9.6	15	10.7				
B84 & Lun B					4	6.2		
Lun K & Lun N			2	7.4				
A44 selfed			1	7.8	3	4.5		
B58 & B90			1	2.4				
D65 & D61					1	2.3	72	5.3
B11 & D65					3	1.7		
D61 & G. 1							16	2.8
B84 & G. 1							12	4.4
B58 & G. 1							1	2.0
Mean Yield of all Families		8.6 10.9		6.1 9.2		3.3 5.2		4.7

A number of exceptionally high-yielding trees are to be found amongst the families of legitimate seedlings, and the yields of some of the highest-yielding individuals are tabulated below:

TABLE XV. *Yields of Individual Seedling Crosses*

Cross Female Male	Yield in lb. per tree of the highest-yielding Tree in each Family		
	1928 series 7½–8½ years	1929 series 7–8 years	1930 series 6–7 years
A 44 x B 58	26.5	25.8	—
B 58 x B 84	—	22.0	21.1
B 84 x D 61	—	20.8	—
A 44 x D 61	20.2	20.0	—
B 58 x B 16	20.6	26.4	—
B 84 x A 44	35.0	29.8	18.7
D 61 x A 44	28.1	—	—

NEW CLONES FROM LEGITIMATE SEEDLINGS

During the years 1930 to 1932 new clones from over 700 legitimate seedlings were established on a small scale on the Experiment Station. From three to six trees were budded in the field with each clone and the majority of these clones were in tapping by the 1st January 1936.

Detailed examination of the vegetative characters of the 120 highest-yielding clones was commenced in March 1937 and 23 clones were selected for large-scale testing. These clones were budded in the field in Block 30 in April and October, and details of the origin and yields of these clones are set out in Table XVI.

Arrangements have been made for testing the most promising of these clones on eighteen estates, to three of which budwood was dispatched for multiplication during the year.

It must be understood that the information set out in Table XVI is from small-scale preliminary tests only and that none of these clones will be recommended for commercial use until it is fully proved.

TABLE XVI. *Yield of the First Selection of Clones made from Legitimate Seedlings*

Clone No.	Origin of Mother-Tree	Yield in pounds per tree per annum		Clone No.	Origin of Mother-Tree	Yield in pounds per tree per annum	
		1936	1937			1936	1937
500	B84 x A44	13.1	15.9	512	B84 x A44	6.0	10.3
501	A44 x Lun N	9.3	18.2	513	B16 x A44	8.0	19.2
502	B16 x A44	9.1	8.7	514	A44 x B58	7.1	14.6
503	A44 x B16	8.1	8.9	515	A44 x D61	6.4	13.9
504	A44 x Lun N	8.6	13.8	516	B84 x A44	5.1	10.4
505	A44 x Lun N	7.1	10.4	517	B84 x A44	4.8	8.5
506	B84 x A44	7.6	13.8	518	D61 x A44	5.2	11.4
507	B84 x A44	6.5	9.0	519	A44 x B16	6.3	10.5
508	B16 x A44	6.5	8.2	520	A44 x B16	5.0	10.1
509	A44 x Lun N	9.2	12.6	521	A44 x B58	5.2	9.4
510	B58 x A44	7.9	10.2	522	B84 x A 44	6.3	12.4
511	A44 x B16	8.1	13.3	...	...	...	...

Note 1. Clones 500, 502 and 508 were budded in the field in November 1930 and were tapped from July to December 1935.

Note 2. Clone 512 was budded in the field in June 1932. The remaining clones were budded in the field in October to November 1931 so that the majority of the buddings whose yields are recorded above were only 6 years old in December 1937.

ILLEGITIMATE SEEDLINGS DERIVED FROM HIGH-YIELDING CLONES

Families of illegitimate seedlings of the clones used as parents of the legitimate seedling crosses of the 1928 and 1929 series were planted in the same blocks as the legitimate seedlings and their yields are directly comparable with them.

The yields of these illegitimate seedling families (Table XVII) are again very satisfactory although they still remain below those of the legitimate seedling families.

TABLE XVII. *Yields of Illegitimate Seedling Families from Clones used in Hand-pollination work from 1928 to 1931. (See Table XIV)*

Family	1928 Series Age on 1-1-37 7 years 8 months		1928 Series Age on 1-1-37 7 years 5 months	
	No. of Trees	Yields in pounds per tree	No. of Trees	Yields in pounds per tree
A 44	152	9.8	82	8.8
B 58	74	8.3	74	7.8
B 84	21	11.6	148	10.5
D 61	27	7.8	47	8.2
B 16	7	6.3	27	8.1
D 65	—	—	29	6.7
B 50	—	—	28	7.3

The yield of the B. 84 family is exceptionally good and although there were four per cent of cases on brown bast it confirms the opinion formed from the yields of the legitimate seedlings of this clone that B. 84 is an excellent parent. It has been used extensively in the 1937 series of hand-pollinations.

A later series of illegitimate seedlings derived from a number of proved clones were planted in 1931 and their yields during 1937 are given in Table XVIII.

TABLE XVIII. *Yields of Illegitimate Seedlings from Proved Clones during the 6th year of Life*

Family	No. of Trees	Yield in pounds per tree	Family	No. of Trees	Yield in pounds per tree
Prang Besar 8	17	6.4	Glenshiel 1	23	3.2
" " 24	14	5.3	Sabrang 24	17	5.9
" " 49	17	7.7	Sungei Reko 9	25	6.4
" " 86	39	6.5	Pilmoor D 61	46	4.4

NEW CLONES FROM ILLEGITIMATE SEEDLINGS

There are in tapping in Blocks 2, 14 E, 16 and 17 D on the Experiment Station some 7,000 illegitimate seedlings and a few legitimate seedlings from which clones had not previously been made.

Forty-three of the highest yielders were selected for small-scale testing and were budded in Block 5 (A) in October 1937. These seedlings are classified as follows:— illegitimate seedlings from Prang Besar Clones—7; from Pilmoor Clones—11; from Tjikadoe seedlings from isolated gardens—8. The collection includes 13 clones made from legitimate seedlings from Pilmoor Clone crosses and 4 clones from other sources.

SEEDLINGS FROM ISOLATED SEED GARDENS

Normal alternate-day tapping on a half-circumference has been continued throughout the year on the families of seedlings from the Tjikadoe isolated seed gardens planted in Block 2, R.R.I. Experiment Station and the yields of the different families are set out in Table XIX.

TABLE XIX. *Summary of Yield Records of Families of Seedlings from the Tjikadoe Isolated Seed Garden.*
(Age in 1937—8 $\frac{1}{4}$ to 9 $\frac{1}{4}$ years)

Family	No. of Trees tapped			Yield in lb. per Tree		
	1935	1936	1937	1935	1936	1937
1 ...	9	9	9	6.6	10.5	12.2
2 ...	13	12	12	7.0	11.6	14.4
3 ...	9	10	10	4.0	7.2	8.5
4 ...	8	10	11	3.2	5.2	7.3
5 ...	10	13	14	2.9	5.1	4.6
6 ...	8	11	11	6.3	9.1	12.3
7 ...	12	12	12	6.5	12.2	14.4
8 ...	9	11	11	3.7	6.2	7.8
9 ...	4	5	5	5.4	9.6	14.1
10 ...	10	9	8	<u>9.6</u>	<u>17.4</u>	<u>15.5</u>
11 ...	10	9	9	<u>3.4</u>	<u>6.6</u>	<u>6.5</u>
12 ...	7	7	7	4.5	9.0	9.5
13 ...	6	9	8	5.5	5.8	6.7
14 ...	6	6	6	4.1	9.4	11.9
15 ...	14	13	13	7.0	11.1	14.3
16 ...	4	7	6	3.6	4.7	7.0
17 ...	9	10	8	<u>8.4</u>	12.2	<u>21.7</u>
18 ...	10	10	10	<u>4.3</u>	7.2	<u>9.2</u>
19 ...	12	13	13	4.6	7.1	8.6
20 ...	15	15	11	<u>9.2</u>	<u>16.8</u>	<u>18.4</u>
21 ...	6	8	8	<u>11.3</u>	<u>9.6</u>	<u>12.0</u>
22 ...	9	9	9	<u>5.6</u>	10.8	14.0
23 ...	9	9	9	5.2	7.7	9.4
24 ...	9	10	10	5.5	8.7	11.5
25 ...	7	7	7	3.1	3.7	5.2
All trees	225	244	237	5.5	9.0	11.1

A new tapping panel was commenced at a height of 30 inches from the ground on 1st July 1937 so that during the year the trees were tapped for six months at the base of the tree and for six months at the new high level. All families, except families 5, 10 and 11, show increases in yield over the 1936 records.

The mean increase for the year from 9.0 pounds per tree to 11.1 pounds per tree is less than the increase shown in the previous year, namely 3.5 pounds per tree, but this may be accounted for by the above mentioned change in tapping height.

The families remain in much the same order of merit as in previous years except for family 17, which has shown a large increase in yield and now takes the first place.

The wide range in yielding capacity of the different seedling families is again apparent and the observations made in the report for 1936 on the value of seedling material obtained from isolated seed gardens may be emphasised.

EARLY DETERMINATION OF YIELDING QUALITIES OF SEEDLINGS

The investigation on the relationship between yields obtained by test-tapping at an early age and yields obtained during normal continuous tapping has been continued. Details of the method of investigation have been published in previous reports. In the summary below the relevant data for the third year of continuous tapping are given with data for previous years.

TABLE XX. *Relationship between Test-tapping Yields and Yields obtained in normal Continuous Tapping*

No. of Test	Age of Trees	Coefficient of correlation between yield of test and total yield at:—		
		6½ to 7½ years	7½ to 8½ years	8½ to 9½ years
1	3½	+ 0.77	+ 0.68	+ 0.58
2	3½	+ 0.75	+ 0.76	+ 0.64
3	4½	+ 0.85	+ 0.77	+ 0.69
4	4½	+ 0.83	+ 0.86	+ 0.65
5	5½	+ 0.80	+ 0.80	+ 0.70
6	5½	+ 0.85	+ 0.83	+ 0.74

Although the coefficients of correlation for the third tapping year are slightly lower than those for the previous years they are nevertheless highly significant. It is possible that the change in tapping height which was made in July 1937 disturbed the closeness of the relationship which the previous figures have demonstrated so clearly.

IV. Physiological Investigations

TREE INJECTION FOR THE DIAGNOSIS OF NUTRIENT DEFICIENCIES

Leaf injection methods, which have given very promising results at the East Malling Research Station, were not found satisfactory on leaves of *Hevea* owing to the presence of latex in the tissues of the leaf. Injection of nutrient solutions into the wood is, however, practicable and a satisfactory technique was devised for use in this experiment.

Trees of clones P.B. 86, Rubana 393 and A.V.R.O.S. 157 on Block 20 on the Experiment Station showing symptoms of chlorosis and leaf scorch were selected and 1,300 cc. of a 0.5 per cent solution supplying nitrogen, phosphate and potash singly and in combination were introduced through a single hole, $\frac{1}{4}$ -inch in diameter, bored diametrically through the main stem at a height of 45 inches from the union. In addition, 0.25 per cent solutions supplying calcium or magnesium; 0.05 per cent solutions supplying iron or manganese; or a further solution containing boron at a concentration of 4 parts per million, were injected.

Each treatment was replicated six times and the controls were untreated trees and trees injected with distilled water.

The experiment was carried out shortly before the 'wintering' season and the principal observations recorded at the most recent inspection, eleven months after treatment, are given below.

The best results were obtained from the potassium treatment, the foliage was green and healthy with no trace of yellowing and scorch and vigorous new growth had been produced from branches where die-back of young twigs had occurred previously.

The nitrogen treatment has, in many cases, increased the severity of leaf scorch symptoms and it would seem that similar observations by other investigators of that effect of nitrogen when potassium is deficient, have been confirmed in this experiment.

The calcium treatment has accelerated the appearance of the symptoms of 'yellowing' of the foliage produced after wintering; more than half of the calcium-treated trees showed yellowing of their foliage when these symptoms were barely discernible on the control trees.

Magnesium treatment has improved the colour of the foliage; this effect is still more pronounced in the iron treatment. Neither treatment has however been effective against leaf scorch symptoms and the die-back of young branches.

The minor elements manganese and boron have had little effect on the foliage, which showed symptoms of yellowing and scorch comparable with those noted on the control trees.

The conclusion is reached that the leaf symptoms of yellowing and scorch as observed on *Hevea* at the Experiment Station, are caused by a deficiency of potassium within the plant.

NUTRITION : POT-CULTURE EXPERIMENTS

Experiments have been commenced to study the effect of deficiencies of nitrogen, phosphorus, potassium, calcium and magnesium on the growth and metabolism of *Hevea*.

The material for this work will consist of buddings of Clone Tjirandji 1 on one year old 'clonal' seedlings from Clone B.D. 10.

Budding was done in the Experiment Station nurseries in December 1937 and planting of the budded stumps in sand-cultures will be carried out when work on the pot-culture site at the laboratory is completed.

STUDIES ON THE USE OF GROWTH PROMOTING SUBSTANCES (PLANT HORMONES) IN PROPAGATION AND TAPPING OF *Hevea*

The experiments described in Section I of this report on the use of chemicals to stimulate the formation of roots form a part of this general investigation. Other aspects of the same subject are also being studied.

A preliminary experiment to test the effect of growth-promoting substances on the rate of bark-renewal was carried out in December on mature seedling trees on a small-holding.

Beta-indolyl-acetic acid as a paste in hydrous lanolin at concentrations of 1 in 1,000, 1 in 5,000, 1 in 50,000 and 1 in 500,000 was applied: (1) to the cambium tissue after stripping the 'bark'; (2) to thin layers of soft phloem tissue (bast) immediately above the cambium; (3) to the tapping panel after scraping off the layer of cork on the renewing bark.

Measurements of the renewing bark will be taken at regular intervals and the work will be continued and extended in 1938.

Further work on treatment of tapping-surfaces and stimulation of bark-renewal, which is being carried out jointly with the Pathological Division at four centres with different climatic and soil conditions, consists of treating the tapped surface for two to three inches above the cut with three different grades of Izal Oil; A, B and C as 3 per cent solutions in Palm Oil; Izal (ordinary) 3 per cent solution in water; and Palm Oil alone; at weekly intervals.

Measurements of bark-thickness were made before treatment and at quarterly intervals thereafter on the treated and control trees.

The treatments will continue until the end of February 1938.

MINOR INVESTIGATIONS

Small-scale investigations undertaken during the year include the following:

Tree Poisoning

An experiment using a wide range of plant-poisons and different methods of application showed that, in the case of old seedling rubber, sodium arsenite (3 lb. per gallon) introduced into a continuous horizontal groove on a ring-barked portion of the main stem at a height of three feet above ground-level, brings about the death of the trees within three months of the time of treatment. Death of roots by translocation of poison prevented the development of coppice shoots below the ringed portion of the stem.

Use of Dyes for colouring cup-coagulated Rubber for recording of Yields in tapping experiments

Twenty dyes, acid and basic dyes in about equal numbers, were tested. These were added to the latex as one per cent. solution of the coagulant and each treatment was replicated ten times.

Examination of the dyed 'biscuits' after one month's exposure to the weather showed that Chlorazol blue G.S. was the most effective dye tested. Next in order came Lissamine green V.S., Safranin, Chlorazol rose B.S. and Methylene blue 2 B.S.

V. Ecological Studies

CULTIVATION OF RUBBER TREES IN ASSOCIATION WITH INDIGENOUS PLANTS AND LEGUMINOUS COVERS

The present report should be read in conjunction with the report on pages 72 to 74 of the Annual Report for 1936.

System 1. Indigenous Covers with minimum of control

Early in 1937 the tree species mentioned in the last report, *i.e.* *Endospermum malaccensis*, several species of *Macaranga*, *Sapium*, *Ficus*, *Anthocephalus cadamba* and *Evodia glabrata*, had grown vigorously enough to overshadow the rubber trees so that drastic lopping was necessary. Plants growing beneath these, *Hornstedtia* sp. ("wild ginger"), *Nephrolepis biserrata*, *Psychotria viridiflora*, *Timonius* spp., *Galearia* spp., grew more vigorously after lopping of the shrub and tree species. The most remarkable change noticed during 1936 and 1937 was the rapid development of *Hornstedtia* and *Nephrolepis* replacing the originally predominant *Trema* species. "Wild-ginger" and species of *Trema* occurred frequently

in small colonies early in 1935. In early 1936 as the plants of *Trema* began to die off, wild ginger spread rapidly. The second generation of *Trema* seedlings appeared to be weaker than the original plants and, in competition with more vigorous herbaceous species, died off earlier. In 1937 the lopping of the tree species, seems to have given the invading herbaceous plants an excellent opportunity to attain dominance. *Hornstedtia* sp. and *Nephrolepis biserrata* may occur as independent colonies but also thrive well when mixed in varying degrees. *Nephrolepis* survives even under a thick growth of wild ginger. As a result of lopping and pruning and also probably owing to the severe competition of the invading perennial herbs, many plants of *Commersonia platyphylla*, *Endospermum malaccensis* and *Anthocephalus cadamba* have died out.

System 2. Growth of Indigenous Covers controlled by Slashing at about three feet at six monthly intervals

Herbaceous species which occur under System 1 occur more abundantly under System 2. *Nephrolepis* and wild ginger are dominant and are rapidly replacing the shrub species. The latter do not spread or regenerate vigorously, probably because of the periodical slashing. In certain areas *Ficus alba* is spreading rapidly and forms the dominant shrub species. Other species including wild ginger often in close association with *Nephrolepis* form the lowest stratum of the cover. A very satisfactory association appears to be *Ficus alba*—*Hornstedtia*—*Nephrolepis*; these three plants together form an excellent close cover. *Ficus alba* which originally occurred only in small isolated patches is now appearing generally over the entire area.

System 3. Similar to 2 but all Ferns are removed

All the species found under Systems 1 and 2 occur here but in larger numbers. Wild ginger is the dominant species but it does not form such a dense ground cover alone as when associated with ferns as in System 2; consequently there has been a considerable amount of erosion on the steeper areas under this system.

System 4. Shrubby Leguminous Covers

The shrubs in plots planted with *Crotalaria anagyroides*, *Tephrosia candida* and *Leucaena glauca* are lopped periodically at a height of about three feet. After the second lopping *Crotalaria* made a poor recovery and by the end of 1936 very few plants remained. *Tephrosia*, on the other hand, recovered very well becoming more sturdy and spreading at first, but in 1937 after the second or third lopping, this shrub also did not recover and deaths are frequent. *Leucaena glauca*, which was very slow in growth at first, became more vigorous and had replaced *Crotalaria* by the

end of 1936. The self-sown seedlings of *Leucaena* occur abundantly and are now taking the place of the dying *Tephrosia*.

Early in 1936 *Desmodium ovalifolium* was planted on the lower edges of the terraces and *Clitoria cajanifolia* on the upper edges. *Desmodium* has developed well and now forms an excellent thick cover on the terraces and has spread between the terraces under the shade of the shrubby covers.

System 5. Creeping Leguminous Covers. Calapogonium muconoides, Centrosema pubescens and Pueraria javanica

By the end of 1936 *Pueraria* had become generally dominant but small colonies of *Calapogonium* and *Centrosema* still remained. During 1937 *Pueraria* appeared to be less vigorous and death of the cover in small patches was frequently observed. The bare patches exposed by the death of *Pueraria* were rapidly invaded by *Centrosema* occasionally mixed with *Calapogonium*.

The experimental area in which the above observations have been made (Block 27, R.R.I.E.S., 50 acres), was planted with clonal seedlings, with control plots of buddings, in November 1934. Planting was on contour terraces at intervals of 22 feet, with the plants 11 feet apart in the rows, and for the first two years the terraces were clean-weeded along strips six to eight feet in width over the entire area. Regular growth-measurements on the rubber trees have been taken by officers of the Soils Division and a full report, including an analysis of these records, will be published jointly by the Botanical and Soils Divisions when the experiment is further advanced. For the present, it will be sufficient to state that differences in the growth of the rubber trees under the five systems of cultivation are small, but there is an indication that the best growth has occurred under System 2.

VI. Field Experiments on the R.R.I. Experiment Station

The undermentioned additions are made to the schedule of field experiments given in previous Annual Reports.

Block	Acreage	Description of Experiment	Date of Commencement
30	40	Clone Trial Experiments R.R.I. New Clones	Planted Nov. 1935 to January 1936, Budded April and October 1937
32	18	New selection blocks for seedlings and buddings from hand-pollinations made during 1937	Planted with seedlings for budding in 1937
33	42		

VII. Field Experiments on Estates

The year under review has seen the greater part of the area allocated to estates for experimental purposes opened up and planted. At the end of the year there remained approximately 600 acres, out of a total of 8,177 acres, still to be allocated and this will be utilised in 1938 by both the Soils and Botanical Divisions for further extensions of the experimental programme. At 31st December 1937, 5,428 acres, distributed on 68 estates, had been planted for experimental purposes. It is obviously too early for any discussion of results to be possible; the majority of estates have only just completed clearing and planting preparatory to budding in the current year. Indirectly, however, a good deal of useful information has been obtained regarding the conduct of experiments on an estate scale and the problems of opening up land from virgin jungle. The present report is confined to a few general notes on those subjects which have been the main concern of this Division.

PLANTING MATERIAL

Experiments fall into four categories—(1) Trials of “proved” clones under a wide range of soil and climatic conditions; (2) Testing new estate or agency clones; (3) Testing new clones developed by the R.R.I. from controlled hand-pollinations; (4) Clonal seed trials.

(1) Opportunity has been taken of the wide range of experiments, comparing different manurial, cultural, and planting systems, to incorporate two or more clones of known yielding-ability with the object of extending our knowledge of their qualities under diverse environments. Every single experiment in this scheme involves the comparison of several types of planting material, thus considerably widening its scope and providing supplementary answers to the main questions. In addition there are five 50-acre clone-trials laid down at the Experimental Sub-Stations where the principal proved clones are being compared in a straight-forward test without additional treatments.

(2) The final selection of estate or agency clones will be made just prior to the time of budding so that the maximum amount of information can be obtained. As a basis of comparison in every case, “proved” clones (principally Tjirandji 1 and Pilmoor B. 84) are being used as controls.

(3) The same applies to those clones which have been raised by the R.R.I. from controlled hand-pollinations. The first selection of new clones has given just over 20 new clones which came up to the yield-selection standard of $7\frac{1}{2}$ lb. dry rubber per tree per

annum in the first tapping year (5—6 years of age) *, but it is expected that from subsequent records and observations the number of clones worthy of field-testing will be reduced by still more vigorous standards.

(4) As with the proved clones, clonal seedlings are tested against buddings both in experiments designed specifically for that purpose and also in conjunction with other treatments. The principal sources of clonal seed are (a) isolated seed gardens (b) monoclonal areas (c) mixed budded areas containing clones known to be good seed-parents.

SUPPLY OF BUDWOOD AND SEEDS

With the large programme of clone and variety trials briefly outlined above the supply and supervision of planting material bulks large at the present stage of work in this Division.

The R.R.I. undertook, save in exceptional circumstances, to supply budwood sufficient only for multiplication purposes, a fact not universally recognised by estates, and a considerable amount of the work in this connection has devolved upon the staff of the Experiment Station. The partial failure of budding in some cases, owing in a large measure to poorly-grown stocks, will result in still heavier demands being made on budwood supplies during 1938.

In regard to clonal seed supplies, the R.R.I. will collect seed of all the families to be tested from various sources for germination and distribution to the experimental areas. In 1937 approximately 25,000 germinated seeds were dispatched, but in the present year the quantities required are considerably larger, necessitating facilities for sorting, germinating, packing and dispatch of seed on a carefully organised basis.

METHODS OF PLANTING

In the majority of experiments the standard recommendations for areas to be budded have been to plant four germinated seed at stake at the corners of a one foot square, in 2-foot cube holes, at a density of 180 points per acre, supplying where necessary with basket plants. The use of budded stumps has been strongly discouraged, except on coastal clay soils where weather conditions and the slower drying-out of the soil makes the planting of such material less precarious. From experience so far gained there has been no reason to modify this recommendation; in fact the difficult planting conditions experienced during the latter part of

* See Section III, *Selection and Breeding*, pages 108 to 117.

1937 served to strengthen the arguments regarding the dangers of budded-stump planting and the merits of the seed-at-stake and field budding system.

Comparison of different methods of opening jungle, with severe and light burning, different methods of soil conservation and cultivation with legumes and natural covers are all receiving special study by both the Soils and Botanical Divisions.

PEST CONTROL

One factor which has limited the progress of experiments on certain areas has been the control of various pests—notably snails and rats. Snails have been particularly damaging to cover-crops whilst there have been several cases of rat-damage on young areas both in the germinated seed stage, immediately after planting, and when the plants are more fully grown. Only by unremitting labour and expense has it been possible to save the more severely attacked areas from complete disaster, and the effective methods of control adopted by managers and their assistants are very greatly appreciated. At the same time, it is realised that to open jungle with the minimum of burning and clearing introduces a pest control problem which cannot be solved easily. The heavy mass of timber and regenerating natural covers between the planting rows severely hampers the application of effective control measures.

EXPERIMENTAL WORK

The laying-out of the experiments in randomised plots has imposed upon estates a duty not normally encountered in commercial planting. In general it may be said that this work has been executed very satisfactorily, notwithstanding in several cases difficulties of slope and topography which render surveying and the marking of boundaries a difficult operation. In some of the larger areas qualified surveyors have been employed for this work. Other operations such as budding, manuring, and collection of growth records come under the category of special operations and to assist estates with large experimental areas of 250 acres or more, the R.R.I. is contributing to the cost of employing special conductors to assist in supervision.

CONCLUSIONS

It is gratifying to record the keenness and enthusiasm shown by the staff of participating estates. With so many estates opening areas at the same time it has sometimes been difficult to give the fullest attention to all estates, and visits must inevitably be in strict rotation. The progress made, however, in the last four months of 1937 augurs well for the results we can expect in the future.

VIII. Advisory Work

CORRESPONDENCE

The volume of correspondence showed a small increase on 1936; approximately 2,000 enquiries were dealt with by letter in addition to those which entailed visits. An analysis of correspondence is given in the Appendix to the report of the Director.

Again the principal subjects of enquiry have concerned choice of planting material and methods of tapping. The development of the scheme of experimental planting on estates has entailed a great deal of correspondence but much of the actual work in this connexion should be regarded as research and not routine advisory work.

ESTATE VISITS

These fall into two categories, (1) visits of a purely advisory nature which deal with botanical problems arising in the routine development and administration of estates, (2) visits where the principal object is to advise on the conduct of research investigations on estates, including the R.R.I. Experiment Station and new experimental plantings. An analysis of the 1937 position is given below.

<i>Member of Staff</i>		<i>Advisory Visits</i>	<i>Research Visits</i>
C. E. T. Mann	...	83	49
C. C. T. Sharp	...	19	102
E. R. Guest	...	—	3
E. D. C. Baptist	...	—	109
N. Wright	...	15	23
K. N. Kaimal	...	1	61
T. V. Vaidyanathan	...	—	103
		—	—
		118	450
		—	—

INTERVIEWS AND VISITORS

The number of visits to the Institute and to the R.R.I. Experiment Station to view and discuss work of a botanical nature, such as choice of clones, value of clonal seedlings and results of, and advice on, tapping of buddings and seedlings, has shown a further increase. The total number of interviews arranged at the laboratory was 174; visitors to the Experiment Station are included in the Manager's report.

LECTURES

The following lectures were given during 1937: --

<i>Venue and Date</i>	<i>Subject</i>	<i>Lecturer</i>
Rengam and District Branch I.S.P. 21st February 1937	"Recent progress of experimental work on Buddings and Seed- lings"	C. E. T. Mann
Taiping Branch I.S.P. 12th July 1937	"Selection of Planting Material for Replant- ing"	C. E. T. Mann
Bentong (Pahang) Branch of I.S.P. 12th September 1937	"Progress of Work on Selection of Superior Planting Material"	C. E. T. Mann
Annual Conference I.S.P. at Kuala Lumpur 17th September 1937.	"Experiments on Tapping Systems"	C. C. T. Sharp

EXHIBITIONS AND SHOWS

The whole staff of the Division remained on duty at the Institute during the three days of the M.A.H.A. Show in August. Visitors were given demonstrations of the routine work of the Division and special exhibits illustrating work on selection and breeding, propagation and tapping were arranged.

District Agricultural Shows were attended at Kuala Kangsar by Mr. C. C. T. Sharp, and at Raub by Dr. E. D. C. Baptist.

PUBLICATIONS

"Tapping of Budded Trees"

C. E. T. Mann. *J.R.R.I.M.* **8** (1937) 5.

"Experiments with Economic Tapping Systems (1) Parts IV and V"

C. C. T. Sharp. *J.R.R.I.M.* **8** (1937) 24.

"The Treatment of the Pruned Surface of Large Stocks of Buddings of *Hevea brasiliensis*"

C. C. T. Sharp. *J.R.R.I.M.* **8** (1937) 39.

"Choice of Clones for Replanted Areas"

C. E. T. Mann and C. G. Akhurst. *J.R.R.I.M.* **8** (1937), 74.

"Experiments on Tapping Systems"

C. C. T. Sharp. *The Planter* **18** (September 1937) 387.

Kuala Lumpur,
18th June, 1938

C. E. T. MANN
Head of Botanical Division

ANNUAL REPORT

PATHOLOGICAL DIVISION

STAFF

Mr. F. Beeley returned from home leave and assumed duty on January 7th, so that for practically the whole of the year the Division was at normal strength.

Mr. K. P. John continued to serve as Assistant Pathologist throughout the year and we record our appreciation of his services.

Mr. H. C. Chuan the Institute's artist and photographer continued his valuable services under the charge of the Division. This section of the Institute's work is increasing year by year and the appointment of an assistant artist was decided upon. A suitable candidate for the appointment was found and is expected to assume duty early in 1938.

We again record the valuable services given by the Asiatic Staff particularly during the difficult period of packing, removal and re-establishment in the new laboratories at Ampang Road.

Our indebtedness to the Government Entomologists assumes greater proportions from year to year and we are grateful to them for their generous assistance during the past year.

GENERAL REMARKS ON PROGRESS OF RESEARCH

During the first half of the year progress of work in the laboratories was seriously handicapped firstly by the congestion in the old building and later by the amount of time and work involved in the removal of the laboratories to the new buildings on Ampang Road. About the end of April the new laboratories of this Division were ready for the continuation of research and by the middle of the year were in full working order.

Further time was taken up by the following:—

- (1) preparation of exhibits in connection with the ceremony of the official opening of the New Laboratories,
- (2) preparing four sets of exhibits for the District Agricultural Shows,
- (3) preparation of the Pests and Diseases section of the (Small-holders) Planting Manual No. 7, and
- (4) preparing the more detailed Planting Manual on Pests and Diseases.

Lectures and general talks were given to the Asiatic Rubber Instructors and a group of new Asiatic Rubber Instructors were

given a short course on rubber-tree diseases and their control, preparatory to taking up their appointments in the various States.

A further large increase in advisory work is recorded for the year 1937, details of which are appended to the Director's report.

Researches on the field aspects of Hevea Leaf Mildew have continued as in previous years, though laboratory work was impossible owing to the removal from the old to the new laboratories during the wintering season. A report of the field investigations was prepared for publication, a summary of which is given under that subject in this report.

The occurrence of both pathological and physiological diseases of young and mature budded trees, in various parts of the country, has received much attention; especially in view of the great amount of interest taken in the progress of the various clones, regarding yield, adaptability to local conditions and recent experimental plantings carried out under the Rubber Regulation scheme.

In regard to Mouldy Rot, further work on the testing of fungicides and mixtures of fungicides with waxes and oils was carried out when the weather was suitable and suitable infected rubber areas available.

Research with a view to the production of suitable sticky bands or "tanglefoot" was necessitated by the large number of enquiries regarding rat and insect damage. The slug and snail pest also merited attention and suitable experiments were carried out to determine more efficacious methods of control in the light of the new discovery of the effectiveness of the chemical poison, "Meta", or metaldehyde.

BACTERIOLOGY

The analyses of soil samples from various manured areas of two estates were continued up to September and the results confirm the general conclusions stated on page 95 of the Annual Report 1936.

Considerable work was carried out during the second half of the year on the nodule bacteria of leguminous cover plants. Organisms were isolated from nodules and their specificity and their nodule-forming properties on various covers were tested in the laboratory. The Division is now in a position to supply cultures of tested strains of *Rhizobium* for experimental inoculation in the field.

Root-Disease Investigations

The eradication of root-disease when replanting old, uneconomic rubber areas was again the most urgent problem under this heading.

The need for eradication is no longer questioned. There is still a good deal of controversy, however, regarding the most economical procedure to adopt when carrying out the process on a commercial scale.

To understand this controversy it is necessary to remember that eradication takes place in two stages. A proportion of the infected material is usually removed, purposely or incidentally, when clearing the original stand. The remainder, being left to rot away *in situ*, gives rise to further losses in the subsequent stand, and eradication is not complete until this subsequent attack has been brought under control.

The severity of the subsequent attack varies inversely with the extent of root removal before replanting. The cost of eradication is therefore the sum of two inversely related components, viz:—

- (1) expenditure on the extraction of infected roots during the removal of the original stand,
- (2) expenditure on the control of the subsequent attack caused by residues of infective material purposely or accidentally left to rot *in situ*.

It is here that controversy arises, for although the mode of variation of each component is known with some degree of accuracy, it is by no means easy to predict the mode of variation of their sum, or to determine from first principles which particular method of eradication will bring this sum to a minimum.

Methods at present in use on estates cover the whole possible range of variation. At one extreme, areas to be replanted are dug over uniformly to a depth of 18-24 inches, all roots being removed, whether healthy or diseased, before planting commences. At the other, the original stand is removed by merely cutting off the trees at ground level; no digging or root extraction is carried out before planting, the intention being to effect eradication solely by means of routine treatment in the replanted stand.

Judging from evidence at present available there is little doubt that minimum cost of eradication will be given by one of the intermediate methods, most probably by the method of selective patch-digging described on pp. 81-83 of the Annual Report for 1936, which has been adopted by the Institute for general recommendation. To set the matter beyond doubt, however, two full-scale field experiments were initiated during the period under review to compare this method statistically with the more important alternatives at present in use.

A minimum of two experiments was necessary, one on an inland and one on a coastal site, the problem on coastal soils

differing in certain important respects from the more general problem encountered in inland areas (see Annual Report for 1936 p. 83).

INLAND REPLANTING EXPERIMENT

The inland experiment was laid down on an estate in Ulu Selangor, where a suitable site was found in an area of 30-years-old rubber which was just about to be replanted.

The site was a rectangular block, 80 acres in extent, where losses from root-disease had been particularly heavy. A preliminary survey showed that disease patches occupied at least 50 per cent of the total area. The main parasite was *Ganoderma pseudoferreum*, but *Fomes lignosus* and *Fomes noxius* were also present.

A randomized block arrangement was adopted allowing for six treatments and five replications. This gave a plot unit of $2\frac{2}{3}$ acres, which was as small as could be used with safety in view of the large size of the individual disease patches.

The treatments were as follows:—

- A. Uniform digging to 18 inches, all roots being removed to this depth whether healthy or diseased.
- B. As A, but digging only to 10 inches.
- C. Disease patches dug over to a depth sufficient to ensure complete removal of infected roots. Remainder of the area dug uniformly to 10 inches without collecting roots.
- D. Disease patches dealt with as in C, but remainder of the area left undug. Apparently healthy trees were felled by jack or grubber to ensure removal of the boles and larger laterals, and to give a further opportunity for root examination. (This is the standard treatment recommended by the Institute).
- E. No systematic digging. Diseased trees were dug out individually, all infected roots being followed up and removed. Healthy trees were dealt with as in D.
- F. No digging or removal of stumps. Trees (both healthy and diseased) were cut off at ground level, the stumps being then poisoned by injection with sodium arsenite.

In an adjoining block of 6 acres a further treatment G, similar to F but omitting the poisoning of the stumps, was compared against F, each treatment being replicated three times in chess-

board arrangement. The purpose of this subsidiary experiment was to provide adequate comparison between G and the remaining treatments, while keeping the area under this treatment as small as possible.

The treatments were chosen to represent as fairly as possible the range of clearing methods actually in use on estates, and to give the maximum number of useful comparisons, *e.g.*

C *vs.* D should show whether it is worth while cultivating the soil outside the limits of the known disease patches (this cultivation is intended to minimise trouble from undetectable sources of infection, see Annual Report for 1936 p. 83).

D *vs.* F should show whether it is necessary to dig over the open central areas of the disease patches

F *vs.* G should show whether poisoning the stumps of felled trees has any significant effect on the root disease situation. (Method F has recently obtained wide publicity, and may prove to have a practical value. Popular views on its efficacy and mode of action however are largely based on misconceptions).

The work was carried out under normal estate conditions under the supervision of the manager and his staff. The pre-treatments were completed by the end of the year and the whole area was then planted as uniformly as possible.

With regard to ground-covers the opportunity was taken to provide a comparison between leguminous bushes and leguminous creepers as accessories in the control of root disease in young replanted areas. The problem of the correct choice of ground-cover to minimise damage from root-disease in such areas has lately aroused considerable interest, the popular view being that bush covers are more valuable than creepers for this purpose, since they succumb quickly and easily to root-disease attack, and thus serve as ready indicators of residual sources of infection. It is not unlikely, however, that the greater efficiency of creepers in suppressing root-disease activity, and in disintegrating infected timber, will be found in practice to outweigh the more obvious advantages of bush-cover, and that creepers in the long run will prove the more satisfactory. Valuable information on this point will be provided by the above experiment.

(N.B.—A special case in which bush-covers may be used with advantage to indicate sources of root-disease infection is quoted below).

COASTAL REPLANTING EXPERIMENT

A site for the coastal replanting experiment was chosen near Klang on a typical coastal soil (peat over clay). The area avail-

able was small, and in order to obtain sufficient replications it was necessary to reduce the number of treatments to four. The lay-out adopted was a 4 x 4 Latin Square, each plot being two acres in area.

The treatments were as follows:—

- A. Uniform digging to 18 inches, all roots being removed to this depth whether healthy or diseased.
- B. As A, but digging only to nine inches.
- C. A modification of A whereby the work is spread over a period of three years. Strips five feet wide were dug along the planting rows before planting. These strips are to be widened to ten feet during 1938, and the remaining strips are to be dug over in 1939.
- D. Known disease patches were dug over to a depth sufficient to ensure complete extraction of infected roots. Apparently healthy trees were jacked out to ensure the removal of the boles and the larger laterals, but no further digging was done except where root-disease was discovered during felling. (This is the method at present recommended by the Institute).

The advantages of C over A are that the work and expenditure are spread over three years, and that deferred digging reduces the cost of the work by taking advantage of the natural processes of root decay. Method C may prove of particular value on the more peaty types of soil, where it is often difficult to detect centres of root-disease infection in the original stand. If the stand is regarded as healthy, however, and all lateral roots are left to rot *in situ* (c.f. method D) it sometimes happens that a heavy attack of *Fomes lignosus* develops during the first 9—12 months after felling in the still green but moribund roots of the original stand. This attack most probably arises from dormant sources of infection brought into activity by felling and draining (see Annual Report for 1936, p. 83), but the possibility of spore infection through the exposed surfaces of the moribund laterals cannot be entirely excluded. In either case, however, the attack can be minimised by employing method A or C. The present experiment will show whether the additional cost of complete root removal is justified.

As in the inland experiment the treatments were completed and the whole area planted by the end of the year. A preliminary report comparing the costs of various treatments in each experi-

ment is being prepared for publication in the *Journal*. These costs represent component (1) of the total cost of eradication (see p. 130 of the present report). Final figures for component (2) will not be available for at least ten years, but it should be possible to estimate these figures with a reasonable degree of accuracy within five years after planting.

Opportunities to lay down further experiments of the above type would be welcomed. Planters or companies wishing to co-operate in such experiments should notify the Institute as soon as possible.

BROWN ROOT DISEASE IN A REPLANTED AREA

An interesting case of Brown Root Disease in a replanted area was observed on a hilly estate in south Perak, where the trunks and branches of the original trees had been used to support the edges of terraces.

At about six months after felling numerous cases of Brown Root Disease appeared among bush cover plants (*Tephrosia Vogeli*) established below the logs on the banks of the terraces. These infections were thought at first to be caused by contact with infected roots overlooked during the clearing of the original stand. Field investigation showed, however, that this was not the case; in every instance the source of infection was found in a neighbouring log. There was no evidence to suggest that these logs had themselves been infected by contact with the soil or with buried infected roots. It was therefore concluded that infection had been caused by wind-blown spores.

Though propagation by spores plays little part in the spread of root disease under normal conditions on rubber plantations in Malaya, this explanation is by no means improbable. *Fomes noxius* is known to cause a serious stem disease of oil palms in this country which is presumably spread by means of spores, while on rare occasions similar stem infections have been found on standing rubber trees.

The attack was rather disturbing at first sight but yielded readily to treatment. No drastic action was taken, since it was considered unlikely that spore infection would continue after the logs had become invaded by normal saprophytic organisms. Instructions were given to keep a close watch on the indicator plants, and to saw out and destroy all log sections found to be infected. This was done and the attack was quickly brought under control.

Although a similar attack occurred on a neighbouring estate no further reports have yet been received from other parts of the country. It is unlikely, therefore, that the problem will prove

serious enough to justify modification of the Institute's recommendations regarding the use of old rubber logs as wash-preventives. Even in the areas where the attack occurred the cost of control was small compared with the obvious benefits derived from wash-prevention. In future, however, it may be advisable to recommend planting bush-covers along the log-bunds to act as indicators. This is already done in most cases.

The more serious root parasites *Fomes lignosus* and *Ganoderma pseudoferreum* are not likely to invade lying timber in this way.

Diseases of the Tapping Panel

MOULDY ROT—(*Ceratostomella fimbriatum*)

The weather for the greater part of the year has been rather dry or with heavy thunderstorms interspersed with periods of bright sun. This disease has therefore not been so much in evidence during 1937 as in previous years, except in a few inland and southern coastal districts, where the topography of the land and local weather conditions have been more favourable to the development of the fungus on the freshly-exposed bark of the tapped panel. In such cases a noticeable feature of the disease is its occurrence in small isolated areas, usually low-lying or on slopes or ravines hemmed in by hills and drained by a sluggish winding river, often flanked by heavy growths of rubber seedlings and *belukar*.

The influence of climate and local rainfall on the incidence of Mouldy Rot is of importance. Rainfall may not be excessive in districts where Mouldy Rot abounds or may even be very much less than in districts where Mouldy Rot is rarely seen. Bright sun with local rain and thunderstorms, together with a drier period in February and March, and a wetter period in November and December are characteristic of Malayan weather, and in most parts of the country Mouldy Rot is in evidence only during the wetter portion of the year. In other parts of the country, however, the period of the day when rain falls is important. Though the Malayan atmosphere is practically saturated with water vapour throughout the night until about 7 or 8 a.m., rapid drying occurs on a sunny, rainless morning so that by midday or 1 p.m. the relative humidity has decreased to about 60 per cent and if no rain occurs at this time the atmosphere in the plantation is capable of effecting a rapid drying of the tapping panels and thus reducing the likelihood of spore-germination and spread of infection.

In some of the inland and southern coastal areas, where Mouldy Rot is particularly troublesome, the occurrence of late

morning or afternoon rains is more frequent than is desirable and may be an important contributing factor to the promotion of sufficiently humid conditions for the mouldy rot fungus to maintain its activity on the tapped bark, in spite of the comparatively light rainfall recorded even during the wet months of the year.

The effect of growths of natural cover on the incidence of this disease is often a subject of discussion and it seems reasonable to conclude that, though the disease is normally more virulent under the more favourable "forestry" conditions, comparative safety can be assured if the covers are slashed to two feet just before the expected wet season and if clean-cleared rentices, eight feet wide, are provided along the rows of trees in order to promote the movement of air currents and a more rapid drying of the bark after the morning dew or rain.

Bearing the above in mind it seems that, until some new form of treatment or economic immunisation of the trees from disease is discovered the present methods of control must continue.

For districts where the disease is more prevalent the tendency is to use weekly applications of the fungicides prepared from tar-oils mixed with inert vegetable or mineral waxes or jellies, in that they are more durable and more resistant to weather than the emulsified tar-oils or white fluids, which are easily washed off the panel by rain and therefore require more frequent application.

BLACK STRIPE AND PATCH CANKER

As in previous years a few cases of the *Phytophthora* diseases of the tapping panel, and the base of the tree generally, have been brought to our notice. Though Black Stripe rarely assumes serious proportions in this country, Patch Canker of the foot and bole of mature buddings is becoming of more frequent occurrence, not only in this country, but also in the rubber-growing areas of the Netherlands East Indies. Though in some cases lightning may be primarily responsible for an attack, in others it would seem as if the budded trees were more susceptible to the disease than normal seedlings, especially in that portion of the stem just above the union. Close planting of many of the new rubber areas during the past few years may also be a factor concerned, in that the atmosphere within such areas below the heavy canopy of foliage is very humid and likely to promote the activity of the *Phytophthora* and *Pythium* types of fungi.

SUNSCORCH OF THE TAPPING PANEL

In the past few years owing to the considerable dry sunny periods experienced in the early part of the year, sunscorch of

the tapping panel has often been reported as Mouldy Rot, owing to the white bloom of *Fusarium* sp. often found on bark so damaged. Trees in exposed situations or on poor soil often have thin hard bark which is difficult to tap and is usually deeply tapped so that a slight heating by the sun of the remaining few cortical cell layers soon causes their death.

Experiments are in progress to determine the possibility of protecting the bark of poor, old rubber areas by means of vegetable oils containing an antiseptic. These experiments were begun in November on four estates, each representative of different climate and soils conditions and on small-holdings where deep tapping and disease are abundant. The indications to date are that the vegetable oil is beneficial to bark renewal.

Stem and Branch Diseases

PINK DISEASE (*Corticium salmonicolor*)

As in previous years this disease has continued to give trouble in young rubber areas and also in leguminous bush covers. Cultures of the fungus isolated from the disease on Hevea, and from a similar disease on *Desmodium ovalifolium*, were inoculated on to the stems and branches of eight 3-years-old rubber trees on the Experiment Station. After a lapse of three months only one of the cultures from Hevea had produced a positive result while none of the cultures from *Desmodium* appeared to affect the rubber tree and the wounds made for inoculation purposes had healed over. Similarly, pieces of diseased tissue of *Desmodium* grafted on to the stem of the rubber tree failed to produce positive infection.

Though these results are inconclusive it should be remembered that microscopically and physiologically the two diseases are closely similar and that the widespread occurrence of disease on the cover plant very likely indicates that conditions may be favourable to attack of the rubber tree, should the rubber tree variety of *Corticium* be present within the area.

The use of less woody or creeping covers would possibly avoid this situation.

INDETERMINATE BARK CANKER

It was reported in the 1935 Annual Report that on the Experiment Station several trees were affected with an unknown bark canker. Some of the cankered areas were (in 1935) scraped deeply and have now shown that, while many of the old unscraped cankers are still in existence the parts scraped have regenerated a healthy bark resembling closely the renewed bark of tapped panels, the only blemishes in such areas being the original deep exploratory

cuts to the wood to discover the depth of the canker. The old untreated cankers do not appear to have spread and in fact appear to be inactive.

DIEBACK OF BUDDINGS

Further evidence has accumulated during the year which indicates that certain clones suffer what might, more reasonably, be termed developmental or adolescent troubles during their early life; even mature buddings in tapping may show dieback symptoms in their sixth or seventh year. In very young plants the early symptoms are the production of numerous, soft, pithy, lateral branches at the apex of the stem. These branches seem to have difficulty in producing a proper foliage and instead are usually found to carry tiny bract-like leaves. In older trees one notices the production of similar numerous branchlets at the tip of the main branches also bearing a poor yellowish foliage, which is often damaged by mites and leaf spot fungi, and which is frequently shed to give place to an even poorer foliage.

Though certain clones *e.g.* S.R. 9, Tj. 1, B.D. 5, P.B. 186, Pilmoor B. 84, are more prone to this form of trouble than others, susceptibility may vary in different districts. The general impression gained is that the symptoms indicate nutritional deficiencies whose effect is to retard the production of woody tissue within the plant, thus reducing the rate of translocation of water and minerals from the roots. The dieback is therefore aggravated by drought especially on hard or impervious subsoils.

Leaf Diseases

LEAF MILDEW (*Oidium Heveae*)

During the year 1937 the general improvement in foliage of rubber trees mentioned in last year's report has been maintained in most districts, the central parts of Selangor being a notable exception.

In Malaya during the season November 1936 to March 1937 the weather was continuously that of the Maritime Tropical Rain Belt unpunctuated by monsoonal influences. The usual heavy rains of November and December failed to arrive and these months showed rainfalls similar to other normal months of the year. On the other hand, failure of the monsoon winds resulted in the absence of the usual very dry period of January and February, instead of which these months show heavy rainfalls as compared with the same months of previous years, though certain small areas such as north Kedah, Kuala Kubu district and the Malacca-

Muar coastal regions proved exceptions and had a dry month in January, the rainfall being below five inches.

In February and March the absence of the dry north east monsoon winds caused local conditions to have maximum influence on local precipitation with the result that freak rainfalls and temperatures were recorded in many parts of the country.

Realising the influence of rain on the wintering of rubber trees it can readily be understood that considerable variation in severity of wintering at any one time was bound to occur, as was actually the case particularly in districts near the foot of the hills west of the main range.

The weather of the tropical rain belt, bright sun with heavy thunderstorms later in the day, appears to favour the rubber trees with the fortunate result that this year, despite the comparative absence of monsoon influences, the trees have wintered and acquired a new foliage which is excellent in colour and size, having suffered from mildew only to a mild extent and that only in certain late-wintering districts which are dealt with in the published report.

The accompanying Table I shows the rainfall for the first five months of the year; the position of the dry period for each district can be noted.

TABLE I
Rainfall in inches

District	Jan.	Feb.	March	April	May	Total for five months
Kuala Lumpur (Sel.)	9.35	12.25	13.64	17.12	5.83	58.19
Sitiawan (Pk.)	7.96	2.78	7.38	15.82	5.20	39.14
Port Dickson (N.S.)	6.79	3.16	2.19	6.91	2.75	21.80
Tampin (N.S.)	5.98	1.23	9.48	6.66	4.35	27.70
Malacca (S.S.)	3.48	2.96	7.09	6.37	10.04	29.94
Kluang (J.)	7.94	2.34	8.82	10.78	16.17	46.05

A summary of the report reads as follows:—

“The general failure of the north east monsoon to bring its usual heavy rains at the end of 1936 and dry weather at the beginning of 1937 has given us a good idea as to the type of wintering and refoliation likely to occur under the normal climatic conditions of the Tropical Rain Forest Belt, the general indications being that such conditions are favourable to the

“development of the rubber tree foliage and unfavourable to an epidemic activity of the leaf mildew fungus *Oidium Heveae*.

“The number of reports (165) of the disease received from estates this year is about the same as last year (161). Similarly owing to continual lack of virulence of the mildew fungus under normal Malayan conditions the sulphur-dusting programmes carried out in various parts of the country were severely curtailed to one or two rounds of dusting or omitted altogether. The use of sulphur-dusting is finding great favour in the control of Thrips, Mites, Spiders and leaf spot damage in young rubber, in valuable rubber-seed-producing areas and the time is coming when most estates will consider a motor or knapsack duster as an essential part of estate equipment which will give an added security against the possibility of heavy losses due to *Oidium Heveae* or other leaf parasites.”

MINOR LEAF DISEASES

Certain diseases, though considered of minor importance in connection with mature rubber trees, cause considerable anxiety when found in areas of valuable young plants obtained from hand-pollinated seed and special buddings. Various leaf spot fungi: *Helminthosporium* sp., *Sclerotrichum* sp., Rim Blights, *Ascochyta* sp., *Phyllosticta*, *Gloeosporium* sp., *Colletotrichum* etc. are often to be found on such material and have been known seriously to retard the early growth of the young plants. Blotching and bleaching of the leaves owing to the sudden exposure of such plants to the direct rays of the sun often results in loss of the entire leading whorl of leaves. Reflection of the sun's heat from the rain-washed surface of the soil has on many occasions led to serious trouble owing to scorching of the cortex near the base of the stem.

The leaf-spot fungi, as well as the mite and spider pests which often accompany them, can be controlled by the application of sulphur-dust at weekly intervals during the period of formation of a new whorl of leaves

The damage by sunscorch can be best avoided by carrying out all new planting at suitable seasons of the year, or by removing the shade from nurseries some two or three weeks before transplantation to the field is intended. Sunscorch of the base of the seedling can best be avoided by ensuring that the soil is well tamped down in the planting hole to avoid later subsidence of the soil to give a concave surface which serves to focus the sun's rays on the plant. If this cannot be assured it is advisable to cover the surface of the soil around the plants with black soil or well-rotted plant detritus.

Instances of damage to young plants by lightning are constantly occurring, leading to the death of the smaller plants or the need for drastic pruning down to healthy tissue in plants up to five or six years old.

Termites

Preliminary tests were carried out during the latter half of the year on a new and promising method of controlling the termite pest.

This method (which was introduced to the industry through commercial channels) consists in injecting small quantities of finely-divided poison-dusts into the exposed earth-trails, injection being carried out by means of a small dust-gun with a fine tapering nozzle. The method depends for its success on the ease and rapidity with which finely-divided adherent dusts can be distributed throughout a termite colony. Provided injection is carried out with the minimum of disturbance to the earth runs, the insects continue to use the treated trails, picking up the poison on their feet and bodies and carrying it back to the central nest. From thence in the course of feeding, grooming etc. it is gradually spread through the remainder of the colony, quite small quantities being sufficient under favourable conditions to destroy the entire population.

The principles of control by means of poison-dusts have been known for many years, and have been exploited widely and successfully for the destruction of termites in structural timber, and in one notable case for the control of a parasitic species burrowing inside the branches of living trees. In these instances, however, the termites have been living in closed colonies within the substance of infested wood, and it has been possible, by judicious use of bore-holes, to reach each colony at several well-distributed points, thus greatly increasing the chances of successful control.

The novelty of the present method lies in the application of a similar technique for the control of a soil-inhabiting species, whose workings can only be reached at a limited number of remote points, and whose method of attack renders it necessary to apply treatment before penetration of the wood has commenced. The usual method of applying poison-dusts under these conditions is to open up a crater at the foot of each newly-infested tree, scraping the earth trails and their contained termites down into the crater and applying the dust to the soil of the crater and to the exposed portions of the bole. By supplementing the main stomach-poison with a rapidly-acting fumigant-dust such as calcium or magnesium cyanide, it is possible in this way to obtain reasonably

TABLE II
Comparison between "Crater" and "Trail-injection" Methods of
Termite Control

Type of Method	Material Used	No. of Trees Treated	Period of Treatment	Result of Census taken at end of March 1938, i.e. 3 months after end of Period of Treatment				
				Recoveries after:—				Deaths of trees per cent
				(1) 1 treatment per cent	(2) 2 treatments per cent	(3) 3 treatments and over per cent	(4) (1) + (2) per cent	(5) Total per cent
"Crater"	"Cynag" and Sodium Silicofluoride	62	July-Dec. 1937	40.3	12.9	11.3	53.2	64.5
								11.3
"Trail-injection"	Commercial Preparation "A"	148	July-Dec. 1937	70.3	17.6	1.4	87.9	89.3
								5.4
	White Arsenic	48	Sept.-Dec. 1937	77.1	10.4	8.3	87.5	95.3
								2.1
								2.1

(This experiment was carried out on Blocks 7, 8, 9, 15, 16, 18, 20, 22 and 25 at the Experiment Station. Half of each block was treated with preparation "A," a quarter with "Cynag" and sodium silicofluoride and the remaining quarter with white arsenic).

TABLE III
Control of Termites by "Trail-injection" Method
Comparison between Commercial Preparation "A" and White Arsenic

Material Used	Period of Treatment	No. of Trees Treated	Result of Census taken on 14.1.38, i.e. 2 months after end of period of treatment				Deaths of trees per cent	
			Recoveries after			Still infected, or reinfected, since end of period of treatment per cent		
			1 treatment per cent	2 treatments per cent	3 treatments per cent			Total per cent
Commercial Preparation "A"	3. 9.37 to 21.11.37	74	59.0	16.2	8.1	83.8	6.8	9.5
White Arsenic	3. 9.37 to 21.11.37	74	64.8	14.9	5.4	85.1	8.1	6.8

(This experiment was carried out on Blocks 19 and 24 at the Experiment Station. Infected trees were numbered serially in order of discovery; odd numbers were treated with Preparation "A" and even numbers with white arsenic).

good control. The method, however, is relatively expensive, large quantities of each dust being required per tree, while the cost of digging the craters is considerable. By the new technique the greater part of this expenditure on labour and materials is avoided without any sacrifice of efficiency (according to the preliminary experiments, in fact, the efficiency of treatment is considerably increased). It is probable, therefore, that the new method will eventually replace the crater method as the standard method of control.

A description of the method with full details of the experiments referred to above will be given in a separate publication. It will be of interest however to quote here the main conclusions reached *viz*:

- (1) that the new trail-injection method of applying poison-dusts for the control of the termite pest of rubber is both cheaper and more efficient than the crater method of application hitherto recommended (see Table II).
- (2) that for use in the trail-injection method the cheap commercial grade of white arsenic is fully as efficient as any of the expensive special preparations at present on the local market (see Tables III and IV).

TABLE IV

Approximate Costs

of the Methods of Control referred to in Tables II and III
(cents per treated tree)

Expenditure Heading	"Crater" Method using Cymag and Sodium Silicofluoride	"Trail-injection" Method using	
		Commercial Preparation "A"	White Arsenic
Labour (excluding inspection)	5 — 10	$\frac{1}{4}$ — $\frac{1}{2}$	$\frac{1}{4}$ — $\frac{1}{2}$
Chemicals	3 — 5	10	$\frac{1}{4}$ — $\frac{1}{2}$
Total	8 — 12	10	$\frac{1}{2}$ — 1

Cost of inspection (which was the same for all treatments) worked out at $1\frac{1}{4}$ cents per acre per round, and 6 cents per treated tree

TABLE V
Analysis of Replies to Questionnaire on the Cockchafer Pest

Size Class	Estates to which Questionnaire was sent		Estates from which replies were received		Response		Data regarding Infested Areas			Degree of Infestation (all Malaya) according to		
	Number	Area (acres)	Number	Area (acres)	by numbers of estates (per cent)	by areas of estates (per cent)	Number of infested estates	Total area of infested estates (acres)	Total size of infested areas (acres)	Number of infested estates (per cent)	Total area of infested estates (per cent)	Size of infested areas (per cent)
Below 100 acres	...	...	29	2,114	...	...	...	...	...	...	...	...
100—500 "	1,577	327,310	81	22,507	5.13	6.88	...	...	...	...	...	...
500—1000 "	379	277,129	86	63,780	22.69	23.01	5	3,761	737	1.32	1.36	0.26
1000—5000 "	530	1,048,696	207	395,349	39.06	37.69	12	28,213	727	2.26	2.69	0.069
Over 5000 "	50	368,567	27	220,427	54.00	69.80	2	15,470	46	4.00	4.19	0.012
Total for estates over 100 acres -	2,536	2,021,702	401	702,063	15.81	34.72	19	47,444	1,510	0.75	2.34	0.074

Cockchafer Pest

QUESTIONNAIRE TO ESTATES

As a result of a marked increase in activity during the previous year (see Annual Report for 1936 pp. 92-93) a questionnaire was circulated to all rubber estates, agency houses, etc., throughout Malaya, early in 1937, asking for detailed information regarding the occurrence, habits and economic status of this pest. A brief analysis of the replies received is given in Table V.

As might be expected, the percentage response to the questionnaire increased with size of estate. This is shown not only by the steady rise in the figures for response through the various size-classes, but also by the fact that in each class (barring the 1000-5000-acres class) the figure based on areas was greater than the figure based on numbers alone. Taking all classes together the percentage response based on areas was more than double the percentage based on numbers. The former is the more truly representative figure, and a response from one-third of the circulated area must be considered reasonably good.

The questionnaire revealed only four previously unrecorded infestations, but provided a considerable amount of useful information concerning the pest, which is being analysed for publication in the *Journal*. Examination of specimens of mature beetles submitted with many of the replies (the questionnaire having been circulated at the commencement of the fighting season) showed that *Psilopholis grandis* Cast. is not the only species responsible for causing damage on rubber plantations. Other species concerned include *Lachnosterna bidentata* Burm., *Leucopholis rorida* Weber, *Leucopholis lactea* Burm. and *Lepidiota stigma* F.

Psilopholis grandis, however, is undoubtedly the most widespread and most destructive species.

INCIDENCE OF THE PEST IN 1937

As mentioned above four new infestations were revealed by the replies to the questionnaire. It would be incorrect, however, to include these among the 1937 records, since in each case the infestation must have been in existence during the previous year. For the purpose of record these infestations will be included in the 1936 figures.

During the 1937 "grub season" ten new infestations were reported, seven being in new, and three in previously recorded localities. These figures bring the total number of recorded outbreaks up to 35, distributed in 23 different localities (see Table VI).

TABLE VI

Outbreaks recorded since the first appearance of the Cockchafer Grub Pest in 1930

Year	Number of New Records	
	Estates or Holdings	Localities
1930—34	5	5
1935	5	2
1936*	15	9
1937	10	7
Total to end of 1937	35	23

The above table shows that during the year under review there was a slight decrease in the rate of spread of the pest, although the figure was still high as compared with the rate prior to 1936. It should also be mentioned that in many infested areas, particularly those first infested in 1935 and 1936, there was a striking reduction in the density of the grub population, probably owing to the increase in activity of insect and fungal parasites.

Of the 35 areas recorded in Table VI only 30 were actively infested during 1937. The distribution of these areas is shown in Table VII.

TABLE VII

Distribution of Areas actively infested during 1937

State or Territory	Areas actively infested during 1937	
	Estates or Holdings	Localities
Negri Sembilan	12	3
Kedah	5	4
Johore	4	4
Perak	3	3
Selangor	2	2
Pahang	2	1
Malacca	1	1
Singapore	1	1
Totals for Malaya ...	30	19

*Including new infestations revealed by the questionnaire early in 1937.

EXPERIMENTS ON CONTROL

Further experiments on the control of the pest were carried out during the flying season (January to March), and again during the second half of the year, commencing as soon as the grubs of the new generation were large enough to cause visible damage to ground-covers.

With regard to the earlier experiments, interesting results were obtained by spraying the surface of the ground, during the period of emergence of the adult beetles, with crude oil applied at rates varying from 1/10 gallon to 2 gallons per square yard. The results are summarised in Table VIII below:—

TABLE VIII

Control of emerging Beetles by means of Crude Oil

Rate of Application (Gallons per Square Yard)	Percentage Kill	Approximate Cost per acre excluding Labour (Straits Dollars)
1/10	0	80
1/5	0	100
1/2	50	400
1	72	800
2	81	1,600

These figures show that the method, though effective, is prohibitive in cost, and cannot therefore be regarded as a practical proposition. Furthermore it was found, later in the year, that the oil had caused very severe damage to the roots of the trees at the heavier rates of application.

Experiments during the latter half of the year were chiefly concerned with soil-fumigation, using a special machine known as a soil injector, which is designed to deliver small and accurately measured doses of liquid fumigants at any desired depth below the surface of the soil. This method has been for many years the standard method of controlling cockchafer grubs in land under intensive cultivation (*e.g.* in forest nurseries in Europe, and in sugar-cane plantations in Queensland) but had formerly been considered too tedious and costly for use in rubber plantations. The above experiments showed, however, that this was not the case. In the first tests, using carbon bisulphide at the standard rate of one 10-gram dose per square foot, a 100 per cent kill of grubs was obtained in the field at a cost, including labour, of approxi-

mately \$150 per acre. By the various expedients of

(a) reducing the size of the dose,

(b) employing diluted emulsions of the fumigant,

(c) increasing the distance between the points of injection,

it was found that this figure could be substantially reduced, and by the end of the year 90-95 per cent kills had been obtained at cost (including labour) of

\$40-50 per acre on medium to heavy soils

and \$25-30 per acre on light soils.

(N.B. The figure for light soils was obtained in a parallel series of experiments carried out by the Agricultural Advisory Department of Imperial Chemical Industries (Malaya) Ltd., to whom the Institute is indebted for permission to quote this result and also various other items of information referred to below).

Carbon bisulphide is an unpleasant and highly dangerous liquid to handle, and efforts were therefore made to discover an equally effective but less objectionable fumigant. It was hoped that orthodichlorobenzene would fulfil these conditions, but field tests (confirmed independently by Imperial Chemical Industries Ltd.) showed that its lethal action was greatly inferior to that of carbon bisulphide. Equally disappointing results were obtained by Imperial Chemical Industries Ltd. with trichlorethylene and monochloronaphthalene. Later, however, they reported that promising kills had been obtained with carbon tetrachloride, a non-inflammable and (to human beings) practically non-poisonous substance, which would be an ideal fumigant for use on estates. Preliminary tests indicate that carbon tetrachloride is somewhat less toxic to the grubs than carbon bisulphide, and will probably be rather more expensive to use. If the increase in the cost of control is not great, however, it may be more than outweighed by the advantage of safety in handling. It is hoped that definite information on the point will be available before the commencement of the 1938 "grub season."

In the meanwhile soil injection with carbon bisulphide can be fully recommended for use on estates. At the costs quoted above it is cheaper and more effective than the only practicable alternative method of grub destruction at present available, *viz.* deep digging and hand collection, and has the great additional advantage of avoiding all root damage and soil disturbance. The method will be of particular interest to estates at the margins of the existing zones of infestation, as it provides a simple and inexpensive means of dealing with incipient outbreaks.

It should be added that the costs given above are based on current prices of carbon bisulphide. There is some indication that these prices may be increased in the near future.

Insect and Other Pests

THRIPS, SPIDERS AND MITES

In regard to Thrips, Spiders and Mites the position shows little change from that recorded in late years. The Institute's Experiment Station was again sufficiently heavily attacked by these insects during the refoiliation season to merit several rounds of sulphur-dusting. The new foliage of mature trees of the western coastal districts was also again observed to be attacked by *Thrips* sp. at the time of inspection for Hevea Leaf Mildew.

CATERPILLARS

Cutworms and Nettlegrubs, larvae of the *Noctuid* and *Lymacodid* families, have occurred in epidemic proportions in a number of young rubber areas during the year, completely stripping both the cover plants and the rubber seedlings of foliage and in some cases eating the green bark from the stems of the rubber seedlings. In mature rubber areas these larvae devour the inner bark remaining after tapping, causing large wounds in the renewing bark.

Control was effected by spraying with a solution of lead arsenate or with kerosene-lead arsenate emulsion. Owing to the present methods of opening up areas by leaving in as much timber as possible and allowing practically all natural forest growths to come in, there is frequently much damage done before control can be effected and areas of ten to twenty acres have been completely cleared of green leaf, though *Tephrosia* sp. and a few fern species may be avoided by the caterpillars.

An attempt to prevent the caterpillars from crawling on to the rubber plants by the use of sticky bands was only partially successful.

The following is a list of the more common species of caterpillars and insects identified as pests of rubber trees or cover plants during the year:—

NAME	TYPE	PLANT ON WHICH FOUND
<i>Prodenia litura</i> (F) ...	Noctuid caterpillar ...	Hevea and cover plants
<i>Mocis undata</i> (F) ...	" " ...	" " " "
<i>Ophiura</i> (<i>Achaea</i>) sp. ...	" " ...	" " " "
<i>Plusia</i> (<i>Phytomelia</i>) sp ...	" " ...	" " " "
<i>Tiracola Plagiata</i> (Walk)	" " ...	" " " "
<i>Cyana amelaena</i> (Hmps)	Lymantriid caterpillar ...	Inner bark of rubber and covers
<i>Cyana Ridleyi</i> (Hmps) ...	" " ...	Cover plants
<i>Acanthopsyche snelleni</i> Heyl.	Psychid case moth	Hevea

<i>Thosea sinensis</i> (Walk)	Limacodid caterpillar	On grasses
<i>Lawana conspersa</i> (Walk)	Flatid Bug (White Fly)	On bush legumes
<i>Pseudococcus</i> sp. ...	Mealy Bug	Bush legumes
<i>Lecanium nigrum</i> (Nietn)	Scale Insect	Hevea and covers
<i>Lepidosaphes</i> sp. ...	" "	Hevea
<i>Aphis laburni</i> (Kalt) ...	Black Fly	Legume covers

In addition to the above, various unidentified species of plant bugs, leaf-eating beetles and crickets have been reported causing damage to various legumes, grass and forest growths and the root-knot nematode has frequently been shown to be the cause of failure of leguminous covers of both creeping and shrub types.

WHITE FLIES

A number of reports of the occurrence of the White Fly *Lawana conspersa* of the insect family *Fulgoridae*, were received during the year. This insect appears to attack several species of wild and ornamental shrubs while it thrives well on bush covers such as *Tephrosia* sp. and *Crotalaria* sp. in rubber estates, when their white cottony larval deposits and young can easily be seen closely adhering to the branches and main stem.

At first a kerosene emulsion was suggested as a possible method of control but this failed entirely to kill off the young, while the adults, scared by the noise of the sprayers, quickly leaped away and flew to neighbouring bushes.

The use of stronger kerosene emulsions with lead arsenate similarly failed and in some cases the spray fluid proved fatal to the foliage and stems. An insecticidal dust consisting of equal quantities of Pyrethrum and sulphur powders gave moderate degree of control but in some cases failed altogether. The use of an oil spray was unsuccessful, the plants being damaged as well as the insects.

Cyanide fumigation by covering the plants over with tarpaulin tents did not appear feasible under rubber estate conditions, but instead an attempt was made to dust infested bushes with the cyanide powders "Cyanogas" and "Cymag," and it was found that early morning dusting while the dew is on, by means of a small hand-duster, gave adequate control of the pest on the Experiment Station. No detrimental effect on the trees owing to the cyanide powder could be detected. Even adult flies 15 to 20 mm. in length soon fell to the ground and died after receiving a light dusting.

COCCID PESTS

Scale insects, Coccid bugs of various species, have been troublesome on young rubber trees in a few instances. Towards the end of

the year the occurrence of a new *Coccid* pest provisionally named *Iepidosaphes* sp. in the Malacca district was investigated by the Senior Government Entomologist. This pest is said to have done considerable damage to many acres of three-year-old rubber causing complete defoliation in some cases. The absence of parasites of the scale in this area appears to be the chief reason for the occurrence of this local epidemic.

ANTS, CRICKETS AND GRASSHOPPERS

Ants (*Formicidae*) Crickets, (*Gryllidae*) and Grasshoppers (*Cryptacanthacrinae*) continue to form the subject of a few enquiries. The former are said to have been found eating the rubber seeds in the nurseries while the crickets, living in boreholes in the ground, will strip the bark from the bole and tap-roots of a year-old tree and will easily split the stem of young seedlings. Grasshoppers occasionally do harm to the foliage of young rubber trees and cover plants. Instances have occurred during the year when the possibility of combating the pest with flame-throwers was considered, as the lead arsenate sprays appeared to have little effect. Flame-throwers are now available for use in the event of a grasshopper or locust plague developing.

There appears to be no economic method of controlling ants at present in use in this country. Experiments in the use of thallium sulphate in syrup or honey medium (Thomson and Johnson, *Bull. Ent. Res.* Vol. 27.1936) will be carried out next year in infested seed beds.

SNAILS AND SLUGS (*Mollusca*)

The Giant Snail *Achatini fulica* (Fer) is recognised as the main representative of this group which is of serious economic importance in Malaya, and a small spiral-shelled snail, *Subulina octona* Brug, has been reported as occurring in large numbers damaging *Centrosema pubescens*. The slug *Vaginula* sp. also attacks both rubber trees and cover plants on occasion.

Experiments were carried out to determine the efficacy of the Meta-Bran bait for controlling these pests and, as a result, a scheme for control was suggested in which the Meta-Bran bait serves to kill off present infestation and calcium arsenate-lime-cement bricks are placed at short distances round the boundaries to prevent further infestation. A short paper dealing with this work was prepared for publication early in 1938 (*J.R.R.I.M.*, Vol. 8, No. 2).

RODENTS

Rats have been responsible for the loss of much valuable rubber-planting material both in nurseries and in the field during

the past year. The present methods of clearing in vogue afford ample cover for breeding and render control measures by hunting and traps very difficult. However, it becomes urgently necessary to obtain some form of protection of the young plants and seed, and to this end the possibility of the use of sticky bands, tanglefoot and ratlime were considered and tried out in practice. A suitable sticky mixture was found which could be easily made in this country and which was economical in use.

A suitable tanglefoot or ratlime is made by mixing together the following ingredients:—

- 4 parts raw linseed oil (boiled till thick and ropy)
- 1 part castor oil
- 1 part powdered resin (local damar will do)

The mixture when cold should be of the consistency of golden syrup.

This sticky mixture is applied in a thin smear to the basal few inches of the stem of the plant to be protected or to the half of the seed away from the micropile. One pound of the mixture is sufficient for the protection of 400-500 rubber seedlings.

DISEASES AND PESTS OF COVER PLANTS

The situation in this respect is similar to that reported for 1936. Pink Disease (*Corticium salmonicolor*) and Rust fungi continue to give trouble though to a less extent owing to the drier weather. Another disease of bush legumes resembling "Pink" at first sight, save that the causal fungus *Irpex subvinosus* forms a thick, purplish felt, also occurs commonly in Malaya but is of little economic importance.

Parasitic lichens of vivid mauve-purple-grey colouring may sometimes attack the stems of bush covers, especially *Crotalaria* sp., causing damage similar to Pink Disease. The surface of the lichen-growth is smooth and not prickly as in *Irpex*.

Caterpillars, as mentioned above, have been reported as damaging leguminous and forest cover plants to a more or less serious extent in various parts of the country.

It is now being recognised that the failure of leguminous cover crops is more often due to the eelworm (*Nematode*) pest than has been generally supposed and the need for investigation of this pest in relation to rubber agriculture calls for attention.

Bacteriology

SOIL

The monthly counts of numbers of bacteria per gramme of soil on certain areas covering a manuring experiment were con-

tinued until September of this year. The present year's records support the brief conclusions recorded in the Annual Report for 1936 p. 95.

NODULE BACTERIA OF LEGUMINOUS PLANTS

In the second half of the year work was carried out with a view to obtaining viable cultures of nodule-organisms from the various leguminous cover-plants used in rubber estates in Malaya. Some sixteen imported cultures of various species of *Rhizobium* and many locally-isolated cultures were tested on young seedlings of leguminous cover-plants, growing in N.-free liquid media, for their nodule-producing and symbiotic properties, as a result of which it was found that, whereas imported cultures did not produce successful beneficial nodulation on local species of legumes, several of the locally-isolated specimens did so. Field experiments laid down by the Soils Division and by some five or six estates have already indicated the superiority of inoculated seed in establishing *Centrosema pubescens* in rubber areas in Malaya. A lecture introducing this work was given in September and published in the *R.R.I. Journal*, Vol. 8, No. 2. A second paper is in course of preparation and will be published shortly.

LATEX

Owing to various circumstances little progress can be recorded in work in latex bacteriology and preservation of latex. Detailed work on this subject in collaboration with the Chemical Division did not commence until the last quarter of the year and though many samples have been examined and much information obtained regarding the hourly changes in the latex on the day of harvesting, the researches have not proceeded far enough to warrant a report at this stage.

FUNGICIDE TESTS

During the wet season field tests were carried out on eight different proprietary and locally-prepared mixtures with a view to determining their efficacy in control of the Mouldy Rot disease of the tapping panel. None of the proprietary fungicides succeeded in obtaining a place on the official White List of fungicides but two of the mixtures are of interest. One consists of a coal-tar oil mixed with wax, petroleum jelly and Diesel oil and is said to give a greater degree of control of Mouldy Rot in areas where conditions are so wet as to render the use of emulsified white fluids valueless. The experiments carried out with the mixtures tended to confirm that view. The second preparation of interest consisted of Izal Oil diluted with locally-made palm oil, the idea

being to obtain a more waterproof coating of the panel which in wet weather will be sufficiently antiseptic to prevent the incidence of Mouldy Rot disease, and in dry weather will prevent the drying out of the newly-tapped bark and thus improve the rate and quality of bark renewal. A suitable concentration of the antiseptic oil in palm oil has already been determined but the effect of the oil on bark renewal needs a few months' further observation before significant bark measurements can be obtained.

Advisory Work

An analysis of correspondence is appended to the Report of the Director. Other details are as follows:—

SPECIMENS EXAMINED

Leaves	...	...	...	...	...	250
Roots	...	...	...	...	...	50
Cover Plants	...	...	...	...	...	42
Bark	...	...	...	...	...	11
Stumps	...	...	...	...	...	3
Branches	...	...	...	...	...	18
Seedlings	...	...	...	...	...	16
Fructifications and Fungus	...	...	...	...	...	13
Insects	...	...	...	...	...	94
Fungicides and Insecticides	...	...	...	...	...	17
Soil (Bacterial Numbers)	...	...	...	...	...	210
Latex (Bacterial Numbers)	...	...	...	...	...	37
Miscellaneous	...	...	...	...	...	3
Total						764

VISITS TO ESTATES

Visits to Estates other than the Experiment Station	83
Visits to the Experiment Station and Small-holdings	41
Total	124

INTERVIEWS	...	...	...	...	...	91
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LECTURES

A lecture on Nodule Bacteria and Leguminous Cover Plants was given at the Annual Conference of the Incorporated Society of Planters, Kuala Lumpur, on the 16th September 1937, by F. Beeley.

PUBLICATIONS

- (1) A paper, being the substance of the above lecture, was published in *The Planter* Vol. 18 No. 9, September 1937, and also in the *R.R.I. Journal*, Vol. 8. No. 2.
by F. Beeley
- (2) A report on the occurrence of Leaf Mildew was published in the *R.R.I. Journal*, Vol. 8, No. 2.
by F. Beeley

CIRCULARS

- (1) A circular entitled "Insect and Rodent Pests of Rubber Trees" was prepared to cover the description and control of those pests not mentioned in the more specialised circulars.
by F. Beeley
- (2) Directions for use of Bacterial Cultures for Experimental Inoculations of Cover Crop Seed by F. Beeley
- (3) The Control of Root-Disease in Young Rubber Areas
by R. P. N. Napper

TOURS

The following extended tours were made during the year:—

By	To	In connection with
(1) F. Beeley	Aerial Survey of Districts west of the main range	Wintering and <i>Oidium Heveae</i> .
(2) F. Beeley	Northern Selangor, Perak, Dindings, Central Selangor Negri Sembilan, Johore Inland, Central lands.	<i>Oidium</i> leaf disease
(3) R. P. N. Napper	Negri Sembilan; North and Central Johore.	Root Disease, Replanting and Cockchafer Pest
(4) R. P. N. Napper	South and Central Perak	Root Disease and Cockchafer Pest
(5) R. P. N. Napper	Perak and Kedah	Root Disease and Cockchafer Pest.

F. BEELEY

Head of Pathological Division

Kuala Lumpur
14th April, 1938

ANNUAL REPORT

CHEMICAL DIVISION

STAFF AND GENERAL

Throughout the whole year the Division had not its full complement of officers. Mr. Hastings was absent on long leave until 29th July 1937 and Mr. Moore was transferred from the Division to take up other duties in the Institute on 22nd April 1937. Just before the end of the year it became possible to take steps to appoint a new officer from England to fill the vacancy caused by Mr. Moore's transfer. The vacancy should be filled early in the new year. Soon after the transfer of Mr. Moore, the major part of the Divisional advisory work was taken over by Mr. Piddlesden.

On 9th March 1937 the Chemical Division staff moved to the Institute's new buildings. By the time the move was made, some but by no means all of the new laboratory equipment to replace that destroyed by fire, had been received. None of the machinery and other apparatus for vulcanisation testing was available and this was not in fact received and installed until November 1937. By the end of the year vulcanisation testing work was just recommencing.

Latex Constituents and X-Ray Studies

LATEX CONSTITUENTS

Dr. Roberts has continued his studies on the constituents of latex and the position to date is that the completed 12-month series of analyses of Bungsar Estate latex has been scrutinised and the findings with respect to seasonal variation summarised in a paper for the *Journal*. The results of analyses of a wide range of types of plantation rubber and latex concentrate have been compared and contrasted in a second paper. The findings to date on the effect of ammoniation on latex have been embodied in a third paper. This last work is not complete, but its further development awaits a fuller description of the non-hydrocarbon constituents, fatty acid complex, crude caoutchol and phosphate complex, than has yet been given. These constituents and the hydrocarbon itself are profoundly changed by ammoniation.

Two papers have been prepared and submitted to the Chemical Society with a view to publication in their *Journal*, on (i) the method for the analysis of latex and raw rubber, incorporating the modifications introduced since the method was first applied and (ii) descriptions of caoutchene and caoutchol, including a diagnosis of these materials as consisting essentially of an

octaterpene and the corresponding octaterpene dihydrate respectively.

The further development of this work has been chiefly concerned with the oxidation products of caoutchene. Interesting materials have been obtained which give promise of containing oxygen in stoichiometric proportions with reference to a C_{80} unit. Existing work on this subject (*cf. e.g.* Mair & Todd, *J.C.S.*, 1932, 386; Bloomfield & Farmer, *J.S.C.I.*, 1935, 126 T) has not yielded products of definite composition. The work now in hand involves the use of a new reagent and of unusually mild conditions. Analytical description of the new products is in hand.

Suitable modification of one of the above oxidative treatments of caoutchene yields a material which while retaining a measure of elasticity, is very sparingly soluble in the usual rubber solvents. It is hoped in the near future to prepare this material in sufficiently large quantities for vulcanisation tests.

Regular analyses of latex from the R.R.I. Small-holding (Ampang Road) and from the 7th Mile Estate Tapping Experiment have proceeded without interruption.

Conclusions as to the effects, if any, on latex composition, of the A.B.C. and Sunderland systems under investigation at 7th Mile Estate cannot yet be drawn.

X-RAY STUDIES

The equipment for this work became available about the middle of the year and a considerable amount of time has necessarily been spent by Mrs. Roberts in assembling, testing and calibrating the various parts of the apparatus. Owing to damage on the outward journey, certain parts had to be reconditioned locally, thus causing delay in the commencement of operations. Owing to unfavourable climatic conditions it has proved impossible to run the X-Ray tube at its maximum efficiency but by means of a suitable water-cooling device and a system of fans it is now possible to obtain photographs. The use of an intensifying screen, while attended with certain disadvantages, serves to counteract the reduced efficiency of the X-Ray tube.

In spite of these difficulties numerous photographs have already been taken. Air-dried sheet, latex films and the newly isolated substances, caoutchene and caoutchol, have been examined at various extensions and certain new features established. The taking of photographs, however, represents only a small amount of the work involved. Much fine measurement and calculation on many photographs is necessary before any final conclusion can be drawn as to the nature of the evidence obtained. Since much of the present rather unsatisfactory state of this branch of rubber

science is due to premature publication it is not proposed to publish any results until a large amount of data has been obtained.

Latex Preservation

GENERAL

Those estates having large-scale bulking-equipment have continued to export the major part of their crop in the form of normal preserved latex. A few other groups not possessing such equipment but having a fairly well-established latex market, have continued to export some of their crop in this form and are about to instal large bulkers in order to retain their markets by ensuring that reasonable uniformity which has now become the insistent demand of the chief users of latex.

A number of estates, favourably situated for transport to the Dunlop latex-concentrate factories, have been able to dispose of the greater part of their daily crop in the form of lightly-ammoniated latex which is subsequently bulked and concentrated for export by Dunlop Plantations Ltd.

Steamer tank shipments have continued to be made from shore bulks at Singapore and Port Swettenham.

COLOUR OF PRESERVED LATEX AND TREATMENT OF SHIPMENT VESSELS

Apart from the preparation of a series of samples showing progressively increasing discolouration, for the use of our London colleagues, the subject of latex-discolouration has neither received nor required further attention, during the year.

The bituminous drum-lining to which reference was made in the last report, proved in shipment trials to America to be unsatisfactory unless applied in two coats; the cost of the preparation is unfortunately high and its use could not therefore be recommended on economic grounds.

Another preparation made available to us by our London colleagues proved very satisfactory in laboratory discolouration trials, but its drying time is too long to permit its use in second-hand drums.

The latex-zinc oxide film has continued to be used in latex drums by some exporters, with the full knowledge and approval of those buyers who are prepared to sacrifice something in stability for the certainty of the excellent colour which this film undoubtedly ensures. Reference was made in the last report to shipment trials of drums treated with modified latex-zinc oxide films which it was hoped would prevent a fall in stability while ensuring at the same time a good colour. These trials proved unsuccessful and so far means have not been found for ensuring both good stability and good colour when films containing zinc oxide are used.

PUTREFACTIVE ODOUR IN PRESERVED LATEX

It was not possible until the close of the year to re-commence the chemico-bacteriological investigations which have been mentioned in earlier reports, which were being made in collaboration with Mr. Beeley, and which had to be placed in abeyance through the exigencies of other work in the Pathological Division. The studies which are now in progress are expected to yield extremely informative data on the causes and prevention of putrefactive odour in preserved latex.

It is interesting to note that one large latex exporter who, on the advice of the Institute, has used ammonia during collection and a powerful tar-acid disinfectant on large bulking tanks, factory utensils and on the structure of the factory building itself for over three years, has had no single complaint of putrefactive odour in the course of that time. It is a virtual certainty that but for these precautions, ammonia-resistant strains of bacteria would have established themselves and buyers' complaints against odour would have been numerous. Other latex-exporters who have not adopted this procedure from the start, have begun to find themselves in difficulties after approximately one year's working.

STABILITY OF PRESERVED LATEX

The stirring-stability technique described in the last report has been applied during the year in a comprehensive study of day-to-day variations in composition, physical properties, and "stability" of fresh and stored latex. Mention is made elsewhere in this report of these studies.

Variations in the technique have been attempted by the substitution of sodium silicofluoride and mixtures of it with magnesium sulphate, for zinc oxide. The results obtained have been conflicting and their precise meaning is not yet understood. It has been observed for instance that in the technique involving stirring in presence of zinc oxide, the "stability" of a latex appears to fall on storage, whereas if sodium silicofluoride is substituted for zinc oxide, "stability" appears to increase on storage. The terms "stability," and "chemical stability" are ill-defined and there is no generally-accepted technique for the measurement of "chemical stability." Slow-speed stirring in the presence of added chemicals attempts to measure the resistance of a latex to coagulation during compounding, but in the face of the conflicting results mentioned above, it is obvious that much remains to be done before a test can be devised which will provide the user with a true indication of the probable behaviour of a latex during compounding and afterwards. At the close of the year a small high-speed stirrer was brought into service and comparative tests have

commenced on the correlation, if any, between the figures obtained with it for "mechanical stability" and those for "chemical stability" by the slow-speed apparatus.

Numerous comparative tests on normal preserved latex, centrifugal and other concentrates, have indicated that the absence of small flocculates as measured by the Dunlop sieving apparatus, does not necessarily presuppose high "stability" as measured by the slow-speed stirring method in presence of zinc oxide.

VISCOSITY-TEMPERATURE RELATIONSHIPS IN PRESERVED LATEX

By means of the Höppler Viscometer and Ultrathermostat, studies have been made on the variation of viscosity with temperature, over a range extending from *circa* 18°C—85°C. The results obtained will shortly be published. They indicate broadly, as would be expected, a pronounced and progressive fall in viscosity with increase in temperature. In a latex having at 18°C. a viscosity of the order of 8 centipoises, a viscosity of the order of 2.5—3.5 centipoises may be expected at 85°C. The fall in viscosity is fairly rapid between the temperatures of 18°C. and 50°C. and thereafter much slower.

DAY-TO-DAY VARIATIONS IN DRY-RUBBER-CONTENT, TOTAL SOLIDS, ACETONE-EXTRACT, ACID-VALUE, "STABILITY," SURFACE TENSION, VISCOSITY AND "CREAMING-EASE" OF LATEX WHEN FRESH, FRESHLY-AMMONIATED AND AFTER STORAGE

During the month of April 1937, latex from a four-acre block of rubber trees adjacent to the Institute, and tapped under the supervision of its officers, began to be subjected to a systematic testing of the properties set out above. The tests were still in progress at the close of the year and will be published when the twelve months' cycle is completed. The various characteristics are being determined on the latex when fresh, immediately after ammoniation and after ten and fifty days' storage. At this stage it is not possible to give a detailed discussion of the findings but it can be indicated that storage after ammoniation invariably induces marked changes in the total amount of acetone-extractable material and in the acid-value thereof; changes occur also in "stability," surface tension and to a lesser extent in viscosity. Whether or not the changes which take place in the various characteristics can be correlated one with another remains to be seen. What appears to be a seasonal effect occurs in "creaming-ease" of the freshly-ammoniated latex.

ALTERNATIVE METHODS OF PRESERVATION

During the year a large number of possible preservative substances, proprietary and otherwise, have been tested in fresh

and very lightly ammoniated latex. Full details cannot be given here because certain promising materials are still under test. Among the materials tested and considered unsuitable, either because of total failure to preserve latex or because uneconomical amounts were required to achieve that end, are the following:—

(i) *Proprietary substances* :—

Siotol C, Sapamine A, Sapamine CH, Nekal AEM, Nipagin M, Preventol Flussig N, Preventol Flussig I, Merthiolate 1: 1000 (sodium ethyl mercury thiosalicylate), Vultamol, Santaxate.

(ii) *Non-proprietary substances* :—

p. Thiocyananiline, p. thiocyanodimethylaniline, benzyl thiocyanate, ethyl thiocyanate, butyl thiocyanate, pyridine betaine thiocyanate, iso-thymol, chlor iso-thymol, ethyl p-hydroxybenzoate, propyl p-hydroxybenzoate, p-chlor m-xyleneol, sodium perborate, ammonium persulphate.

In spite of the fact that so many bactericides which are effective in other media, fail to sterilise and preserve fresh and lightly-ammoniated latex, there are indications that the search for preservatives alternative to or functional when assisted by small quantities only of ammonia, may prove fruitful. Recent shipment trials with one such disinfectant, applied in an amount equal to 0.2 per cent by weight on the latex and assisted by *circa* 0.1 per cent ammonia were encouraging and further trials with it are in progress.

Concentration of Latex

CONCENTRATION BY CREAMING

The search for new creaming agents has been continued during the year as opportunity offered. No new creamers have however been found. Among the materials which were tried without success were caustic soda extracts of

- (i) rice bran
- (ii) "taro" (*colocasic antiquorum*)
- (iii) "Dhal" bran.

Some attention was also paid to creaming by means of

- (i) Konnyaku meal
- and (ii) pectate pulp.

Neither of these creamers is considered superior to Tragon-A (tragon seed-gum); pectate pulp gave uniformly inferior performance.

Further work has been carried out with the "seed-creamer" to which reference was made in the last report. The results obtained add further weight to the view then expressed that it has commercial promise. Unlike Tragon-A it does not depend for high creaming efficiency on high ammonia concentration, and the creaming operation can be performed at lower ammonia concentration with less resultant loss of ammonia in the waste serum. It has proved specially useful in conjunction with latex disinfectants, in experiments on the preparation of concentrates of unusually low ammonia-content. Trial shipments of such concentrates were in course of preparation at the close of the year.

The synthetic creaming agent referred to in the last report has been employed in the preparation of several fairly large sample batches of high-D.R.C. cream for test by our London colleagues and latex users in England and America. Reports received up to the close of the year were disappointing and no user has so far been found who has a special preference for this type of cream, which gives a sticky, slow-drying film with poor tensile properties.

CONCENTRATION BY CENTRIFUGING

In the first half of the year no experimentation was possible owing to the absence of a centrifuge. A small hand-driven machine became available locally and this, after conversion to power-drive, has been in operation during the last five months of the year. It has been employed not from the viewpoint of improving efficiency by variation in machine design, but for the preparation of special purified concentrates. A number of trials have been made in which the effect of repeated dilution and re-concentration on the composition of the concentrate has been examined, systematically. Tests were carried out at every stage for D.R.C., total solids, acetone-extract, acid-value, viscosity, surface tension, stability and nitrogen content. The results of these trials are now being prepared for publication. In one trial it was found possible to dilute and re-concentrate no fewer than twenty-seven times before clotting commenced. It may be mentioned that even by this very exhaustive washing, the rubber from the final concentrate was not freed entirely from nitrogen.

CONCENTRATION BY EVAPORATION

In the second quarter of the year it became possible to recommence work with the small evaporator designed by the scientific officers of the London Advisory Committee and a 200-gallon sample batch of evaporated creamed latex containing approximately 67 per cent of dry rubber was despatched for

distribution by our London colleagues to interested latex users. During the preparation of this bulk, which was made in a series of small daily batches, advantage was taken to test the physical characteristics of each small lot of concentrate. Interesting variations were noted for which the explanation has not so far been found. The general impression left by this bulk preparation as to the value of the evaporator as an estate machine was that larger machines of this type are unlikely to prove suitable for estate use. The rate of evaporation is low, there is too much loss of rubber by over-drying on the coils, and there is a large loss of ammonia which would prove too expensive to recover.

The evaporated cream produced by the machine is however a valuable form of concentrate, in that it has a very high dry-rubber-content without at the same time a high proportion of non-rubber constituents. If more efficient machines were available for its production, this type of concentrate would find markets.

Later in the year the machine was employed in the preparation of comparable concentrates. From a single batch of field latex, evaporated cream, evaporated centrifugal concentrate and simple evaporated latex were prepared and their physical and chemical properties determined. The results obtained may be published later, when further trials of the same kind have been made.

CONCENTRATION BY FILTRATION

Following upon the preliminary trials with locally-made porous vessels reported last year, our London colleagues obtained for us, after a good deal of necessary experimentation in London on our behalf, samples of English-made porous vessels for trial here. It has not been possible to make trials with them this year, but the necessary mechanical accessories are now almost completed and trials will commence shortly.

Latex Coagulants

Formic acid is now in almost universal use on estates; a few continue to use acetic acid and still fewer, sulphuric acid. Every opportunity has been taken to persuade against the use of sulphuric acid by this minority.

On small-holdings the Asiatic Rubber Instructors have continued to do all in their power to dissuade small-holders from the use of sulphuric acid and alum, and in many cases their efforts have been successful. Where they have not, they have been compelled to choose the lesser evil and instruct the small-holder in

the correct use of sulphuric acid so as to reduce the chances of promoting possible inferior properties in the rubber.

Copper Contamination of Latex and Rubber

Since the publication last year of the Institute's work on the possible contamination of latex by copper from brass sieves and other brass parts of factory utensils and machinery, the use of monel metal for sieves has increased with very pleasing rapidity on estates making sheet rubber. Similarly, brass in other factory accessories has in many cases been replaced by monel metal.

Asiatic Rubber Instructors have also had some success with small-holders, though their task is made much more difficult by the poverty of the average small-holder and the comparatively high cost of monel metal gauze as against brass.

Preparation of Modified Rubbers

RUBBERS HAVING THE PROPERTY OF LOW WATER-ABSORPTION

Reference was made in the last report to the preparation of a works-trial batch of rubber for test by a cable manufacturer. The report on this batch was unfortunately very unfavourable, and it is now increasingly evident that the papain-digestion process is liable to give uncertain results with large-scale batches.

Further experiments have been made by Mr. Hastings during the second half of the year, on the enzymic treatment of latex and latex concentrates. Variations have also been made in the nature of the coagulants employed for subsequent coagulation, but at the close of the year no products had been obtained, which had water-absorptions as low as those shown by the rubber from triple-centrifuged latex.

Repetition of earlier work, of which the records were destroyed by fire, has established beyond all doubt that by no water-soaking treatment, however prolonged, whether on sheet of normal thickness or unusual thinness, can a sheet rubber of satisfactorily low water-absorption be produced.

SOFT RUBBER AND FUNDAMENTAL WORK ON THE CAUSES OF VARIABILITY IN PLASTICITY

Rubber from Individual Trees

A regular day-to-day preparation of rubber from a number of individual trees is proceeding with a view to ascertaining the effect of seasonal and other climatic variations on plasticity. The samples are prepared by a rigidly-controlled technique so as to avoid, as far as it is humanly possible, variation due to preparation

procedure. Considerable variation has been found not only as between tree and tree but also in the rubbers from the same tree. Systematic determinations of the acetone-extract and acid-values of the samples is proceeding but the indications at present are that no correlation will be found either between the acetone-soluble matter or its acid-value and the plasticity of the rubber.

Colour of Smoked Sheet and Plasticity

Mention was made in the last report of an attempt to test the opinion held by certain users that dark-coloured rubbers are usually soft and light-coloured rubbers hard. For this work the plasticity of the normal product, manufactured on a certain specified day on a hundred different estates, was determined. The results of this work were destroyed by fire. The experiment has now been repeated and the plasticity tests are almost completed. Experiments have also been made in which a number of sheets prepared at the Institute from the same batch of latex by a standard procedure, were dried in a number of different estate smoke-houses, chosen so as to give a wide range of colour in the resultant smoked sheet. The results are not yet available.

The plasticity-testing is being carried out with two different types of plastometer, the one being of the Williams type and the other being the Mooney Shearing Disc instrument. It is notable that the two types of instruments do not always place a given series of rubbers in the same order of hardness.

Preparation of Soft Commercial Rubbers

During the year experiments have been made on the incorporation of "peptising agents" into latex with a view to obtaining a soft rubber as a result of the effect of the heat applied during smoking. In the early trials phenylhydrazine hydrochloride solution was applied to latex shortly before the acid and the resulting rubber was machined and dried in the ordinary way. The rubbers obtained were encouragingly soft and this finding was amply confirmed by our London colleagues to whom samples were sent. Phenylhydrazine hydrochloride is however a toxic substance and although the results obtained with it were encouraging its use could not be recommended to estates because of the health hazard. By the courtesy of E.I. Du Pont de Nemours & Co. of America a small supply of a non-toxic "peptising agent" was obtained. The material is however insoluble in water though soluble in acetone, which itself is a coagulant for latex. These facts introduced the problem of uniform incorporation into latex. In early trials the incorporation lacked uniformity and the sheets of rubber obtained were unsatisfactory because they had hard

and soft places on their surfaces. The degree of softening was however such as to encourage further efforts to achieve uniform incorporation and a general as distinct from localised softening. Towards the end of the year means were found for obtaining a perfectly uniform dispersion of the material throughout the body of the latex. Uniformly soft rubbers resulted, which have encouraged the view that the process has commercial possibilities. With the arrival of further supplies of the "peptising agent" the work will be pressed forward and trial batches will be prepared for manufacturers' tests. Unlike other processes for the preparation of soft rubber it would not involve estates in the installation of large and expensive plant; one small machine only would be required costing in the neighbourhood of £40 and existing estate equipment would be employed for all other operations.

CHLORINATED AND BROMINATED RUBBERS FROM LATEX

As a result of work carried out by our colleagues in London, procedure was recommended to us for the preparation of lightly-chlorinated and brominated rubbers from latex. The application of the procedure to fresh latex as distinct from the ammoniated product available in England produced its difficulties, but samples of rubber containing varying amounts of combined chlorine and with and without added antioxidants, were eventually prepared and despatched to London for test. Up to the close of the year a satisfactory modification of the procedure for the preparation of brominated rubbers had not eventuated, but at the time of writing it is believed that the difficulties have been overcome.

Clone Rubber

Owing to the fact that the vulcanising equipment could not be brought into service until almost the end of the year, vulcanisation testing and ageing work has not been possible. Plasticity-testing was commenced however on the clonal rubbers from Block 5 of the Institute's Experiment Station, but results are not yet sufficiently numerous to warrant discussion.

The Drying of Rubber

The paper mentioned in the last report, describing experiments on the theory of drying as applied to rubber, has been completed and published. Further work is in hand on the problem of "after-dripping". It has been very frequently observed recently that sheet rubber machined on high-speed batteries often has the peculiar characteristic of exuding large amounts of free water

as soon as it enters the warm atmosphere of the smoke-house; this despite the fact of its having been allowed to drain very thoroughly in free air before introduction into the house. Where this occurs, condensation troubles frequently arise and the whole phenomenon has therefore an important bearing on smoke-house design.

The experimental smoke-house mentioned in the last report was erected at the Experiment Station and has been under test during the second half of the year. The house is a 700-lb. per day unit, of the "straight-through" type. It is sought to produce a cheap building having the advantages of present-day smoke-houses without some of their disadvantages and possessing at the same time a high fuel-efficiency. The difficulties encountered have been both unexpected and numerous. The original design embodied sound theoretical principles which it appeared could be translated easily into practice; the reverse proved to be the case and many modifications have become necessary in order to obtain even passable performance. At the close of the year some but not all the difficulties had been overcome, but houses of this type cannot yet it is felt be recommended to estates with the assurance of satisfactory performance.

Sheeting Batteries

The year has seen the installation of a number of the new "Guthrie R Type" machines on Malayan estates and the introduction of a new type, again evolved by Mr. Reginato of Ulu Tiram Estate and marketed under the style of the "Guthrie Cadet" battery. This consists of a single compact unit of four pairs of rolls with short intermediate chutes designed to keep the coagulum properly centred. It is specially suitable for small estates because it requires two operatives only.

Advisory Work and Routine Chemical Examinations

The appendix to the Directors' report indicates that over 1,000 letters were again despatched from the Division during the year. These covered a wide range of estate enquiries, of which smoked sheet, smoke-houses, and latex-preservation and testing were the major items. Nearly 600 specimens and samples were received for examination or analysis. The number of personal visits to the Division by estate managers and others totalled 349; this is far in excess of the figure for 1936.

The revised advisory pamphlet on Subur Type Smoke-houses and the new pamphlet on the Inexpensive Temporary Smoke-house, have been well received.

Collaboration with Allied and other Organisations

There has been the closest contact with the scientific officers of the London Advisory Committee throughout the year. Experimental samples of special rubbers and latex have been tested by them on our behalf and brought to the notice of users in England. Patent applications have also been negotiated for us. Their assistance in all these matters has been of great value.

The Division has kept in touch with the Crude Rubber Committee of the American Chemical Society (Rubber Division). This Committee proposed some time ago a special recipe for rubber mixes used in vulcanisation testing. This recipe has been adopted at the Institute.

The officers of the Ceylon Rubber Research Scheme have corresponded freely with us on all matters of mutual interest.

The very friendly relationship between the officers of the B. F. Goodrich Research Station in Kuala Lumpur and the Divisional staff, has been maintained, and advice and assistance has been given us on numerous occasions.

During the month of December, Mr. J. Wilson, the newly appointed Director of the British Rubber Producers' Research Association, visited Malaya for the purpose of studying various aspects of rubber production. Officers of the Chemical Division took part in numerous discussions with him and accompanied him on tour during the period of his stay in Malaya.

Lectures

The following lectures were given during the year:—

<i>Lecturer</i>		<i>Place</i>	<i>Title</i>
K. C. Roberts	...	Nilai—Labu I. S. P. Branch, at Nilai	"From Raw Rubber to the Vulcanised Rubber Article"
J. H. Piddlesden	...	Central Johore I.S.P. Branch, at Kluang, Johore	"Sheet Manufacture with Special Re- ference to Dry- ing"
J. H. Piddlesden	...	South Johore I.S.P. Branch, at Johore Bahru, Johore	"The Preparation of Rubber with Special Reference to Drying"

Publications

- (1) "The Drying of Rubber"
by J. H. Piddlesden
J.R.R.I.M. **7** (1937) 117
- (2) "Subur" Type Smoke-houses
 - (a) Original Type With Furnaces Below Ground Level
 - (b) Modified Type With Furnaces Above Ground Level
 by A. Moore and J. H. Piddlesden
J.R.R.I.M. **7** (1937) 147
- (3) Note on an Inexpensive Temporary Smoke-house
by A. Moore
J.R.R.I.M. **7** (1937) 165
- (4) Notes on Centrifugal Concentration of Latex
by J. H. Piddlesden
J.R.R.I.M. **7** (1937) 169

Malayan Agri-Horticultural Show

This year there was no staged exhibit at the show-ground itself, but the Institute was open to the public and demonstrations were given in the Chemical in common with other Divisions.

Dr. Rhodes, Mr. Moore and Mr. Piddlesden acted as judges in the All-Malayan Small-holders Rubber Competition. Prize-winning and other exhibits were displayed in the show-ground.

Empire Exhibition Glasgow 1938

Chemical Division Officers have been responsible for the Institute's share in the Malayan exhibit. At the close of the year, work on the rubber estate diorama and the scale-model of a rubber factory was well in hand.

EDGAR RHODES

Head of Chemical Division

Kuala Lumpur,

29th January, 1938

ANNUAL REPORT

EXPERIMENT STATION

1. ACREAGE STATEMENT

Planted	...	...	1,056.25	acres
Building sites, and Roads	...	...	56.50	"
Elephant Belt	...	...	64.00	"
Reserve Area	...	...	174.45	"
			1,351.20	"

Planted

(In bearing as at 31.12.37)	...	...	527.25	acres
(Immature (including nurseries))	...	...	529.00	"
			1,056.25	"

N.B.—Not included in the above statement are two seed gardens of a total of 10 acres, in the Forest Reserve, held under permit. These areas are reserved for work on *Hevea spruciana*.

2. DISTRIBUTION OF LAND

Botanical Division	...	...	726.75	acres
Soils Division	...	...	329.50	"
Pathological Division	...	...	—	"
Chemical Division	...	...	—	"
Building Sites	...	...	56.50	"
Elephant Belt	...	...	64.00	"
Reserve Area	...	...	174.45	"
			1,351.20	"

Latex and rubber for examination and experimental work by the Chemical Division is obtained, as required, from the Botanical and Soils Divisions Blocks.

The Pathological Division carries out routine Pest and Disease inspection over the whole planted area.

Experimental work on the control of pests and diseases and on problems concerned with the collection and transport of latex, by Pathological and Chemical Divisions respectively, is carried out on Botanical and Soils Divisions Blocks by arrangement with those Divisions.

3. CLEARING

During the year under review a total of 60 acres of jungle was felled and cleared for planting. A further 1.5 acres of reserve land, within the Building site, was planted for nurseries.

Details are as follows:—

Block 32 (Botanical Division)—18 acres, and

Block 33 (Botanical Division)—42 acres

Felled, burnt off, lined and planted, to be budded later with material from seedling crosses made in 1937.

In both these areas the method adopted was to fell the jungle early in January. The clearings were then burnt off three weeks after completion of felling. A light burn resulted and little scorching of the large timber or soil was to be seen.

The area was then lined for 217 plants per acre; all the lying timber was cleared from strips 8 ft. wide, from north to south, and stumping up to 8 inches was also carried out.

The timber and stumps removed were swung between planting rows across the slope of the hill to arrest erosion.

Block 1

A nursery was established so that material will be available for demonstrations and tuition in budding work during 1938.

4. LINING, HOLING AND PLANTING

Blocks 32 and 33 (60 acres)

These areas were lined 20' $\times$ 10'.

Holing 2' $\times$ 2' $\times$ 2' was carried out, and unselected estate seed, germinated in beds, was planted out four per point. Seed fell early in 1937, and to ensure success four ungerminated seed were also planted at each point. Thinning out will be done early in January 1938.

Block 1

Seed for this nursery was collected from seedling areas on the Station, and was germinated and planted out 1' $\times$ 1'.

5. NURSERIES

Block 1—Main Multiplication Nursery. 8 acres

Budding operations were carried out, buddings from 23 new clones, which have been selected for large-scale testing on experimental areas, were established in multiplication beds.

Budwood from various clones was cut and despatched to estates on which the development of experimental areas is in progress under agreements between the Companies, the Controller of Rubber and the Rubber Research Institute of Malaya.

Block 4B. 5 acres

There still remain a few beds containing budwood material reserved for experimental work; the remainder of the area has been planted with seed of *Tephrosia candida*.

Block 6A

Work on the development of root systems of a number of families of clonal seedlings is being carried out by Dr. E. D. C. Baptist. *Desmodium ovalifolium* planted in the open spaces in this nursery, has become well-established. Cuttings are taken from this area for planting in new clearings.

6. MANURIAL TREATMENTS

During the year 1936, "bronzing" or "yellowing" of the leaves of portions of fields on the eastern side of the Station was noticed.

The Director, in consultation with the Soils Division, decided on a manuring programme which will be suitable for the soil in these areas, and a mixture called R.R.I. Standard Mixture No. 1 was made up by a local fertilizer firm as follows:—

Ammonium sulphate	8 parts	} This has an analysis of:
Christmas Island		
rock-phosphate	5 "	
Potassium sulphate	7 "	
		N. 8.2 per cent
		P ₂ O ₅ 9.2 " "
		K ₂ O 16.8 " "

For future applications, this has been modified to include soluble phosphates.

The fertilizer was applied in the Blocks mentioned below:—

Block	Rate of Application				Remarks
1 Multiplication Nursery	5	cwt.	per	acre	
1A ...	1½	lb.	per	tree	Supplies only
2 ...	2	"	"	"	
3 ...	3¼	"	"	"	
3A ...	1½	"	"	"	
4C ...	2½	"	"	"	
5A ...	¼	"	"	"	
9A ...	½	"	"	"	
14 C & D	...				
15 ...	from	1lb. to	}	Backward areas only	
		2lb. per tree			

<i>Block</i>	<i>Rate of Application</i>				<i>Remarks</i>
16 N & S ...	3½	lb.	per	tree	
16F ...	½	"	"	"	
17B ...	½	"	"	"	
17C ...	2	"	"	"	High land only
18 ...	2½	"	"	"	
19 Cultvn. Expt.	1½	"	"	"	
20 & 20A ...	2	"	"	"	
21 ...	3½	"	"	"	
22 N & S ...	1¼	"	"	"	
25 Secs. 1, 2 & 3	1½	"	"	"	
25 South ...	3½	"	"	"	

Block 6—Manurial Trial (Soils Division)

This Block received its annual application of manure in March. Leaves, debris and covers were removed in eight-foot strips running north to south. Manure was applied and dug in to 3 inches. Control unmanured plots were similarly cleared in strips and forked to 3 inches.

Block 23—Soil Exhaustion Experiment (Soils Division)

This Block was manured in May. Details of the experiment, which will provide a comparison between Sterameal Young Rubber mixture and Enpekay No. 1, are to be found in 1936 Annual Report.

Block 31—Manuring Experiment (Soils Division)

The second dressing of fertilizers was applied in May. At those points where a buddable plant occurred the normal dressing was applied, whilst at those points where there was no buddable plant a double dressing was put down.

The amounts of fertilizers for the normal dressing were as follows:—

"B" plots received 3½ oz. per point of sulphate of ammonia

"C" plots received $\left\{ \begin{array}{l} 3½ \text{ oz. per point of sulphate of ammonia} \\ 2 \text{ oz. per point of sulphate of potash} \end{array} \right.$

"D" plots received 4½ oz. per point of "Nicifos B"

"E" plots received $\left\{ \begin{array}{l} 2 \text{ oz. per point conc. superphosphate} \\ 2 \text{ oz. per point sulphate of potash} \end{array} \right.$

"F" plots received 6 oz. per point "Enpekay No. 1"

Block 13A—Manurial Trial (Soils Division)

This Block of $2\frac{1}{2}$ acres is divided into 16 equal plots, comprising four replications. The first application of fertilizers was at planting in November 1936 and the second application in June 1937.

Details are as follows:—

“A” plots received per point in June 4 oz. Enpekay 2

“B” plots received per point in June 4 oz. Enpekay 2

“C” plots received per point in June 4 oz. Complete mixture

“D” plots received per point in June 4 oz. Enpekay 2

Details of the first applications are in the 1936 Annual Report.

Block 14 C and D—Density-of-Planting Experiment

The backward plot in this area mentioned in 1936 report received a second dressing similar to the first.

Block 15A

Clonal seedlings in this area seen to be backward were manured with “Supram” at the rate of 4 oz. per point.

Blocks 7 and 8—Cover Plants and Clean-weeding (Soils Division)

Basic slag was broadcast over the areas in cover at the rate of 1 cwt. per acre. Basic slag at the same rate was broadcast in the previous year, but little or no regeneration followed as the covers were too depleted to gain any benefit.

Block 24—Soil Erosion Experiment (Soils Division)

Manuring of the covers in this area was done exactly as in 1936 and was fully described in that report.

Cover Crop Manuring

A mixture called R.R.I. Standard Mixture No. 2 was prepared on the instructions of the Soils Division as follows:—

Ammonium sulphate	...	...	2 parts
Christmas Island rock-phosphate	...	2	„
Potassium sulphate	...	...	1 part
This has an analysis of N		8.2	per cent
	P ₂ O ₅	15.0	„ „
	K ₂ O	9.6	„ „

This mixture was broadcast over the covers in Block 4B, 5 and 20 at the rate of 2 cwt. per acre. This cover-crop mixture has now been changed slightly and further applications will consist of:—

Ammonium sulphate	2 parts
Rock phosphate	1 part
Conc. superphosphate	1 „
Potassium sulphate	1 „

Block 17—Clonal Seed Trial. 17D North (10 acres)

A small and backward area was excised from the experimental Block and now forms a manuring experiment under the control of the Soils Division.

There are seven treatments, replicated three times:—

- A Control unmanured
- B Nitrogen
- C Nitrogen & Phosphate (super)
- D Nitrogen & Potash
- E Nitrogen & Potash & Phosphate (super)
- F Nitrogen & Phosphate (Ammophos)
- H Nitrogen & ground limestone.

The first application was given in November and further applications will be six-monthly. Leaf samples are collected and analysed quarterly by the Soils Division.

Blocks 32 and 33—New Clearings

As it is important that there should be at least one buddable plant at every point in these Blocks by October 1938, each point was manured at planting with 4 oz. of the following mixtures:—

Sulphate of ammonia	...	...	5 parts
Nicifos "B"	...	...	2 „
Christmas Island rock phosphate	...	...	3 „
Sulphate of potash	...	...	5 „

This has an analysis of:—

Nitrogen	...	...	9.3 per cent
Phosphoric acid	...	...	10.0 „
Potash	...	...	16.0 „

7. SOIL EXHAUSTION EXPERIMENT BLOCK 23 (65 ACRES)

In this Block an area of 29 acres has been brought under the knife for experiments on latex from various tapping systems. The remainder of the area is still immature.

8. THINNING-OUT

Thinning-out was done as detailed below. As in previous years, trees which were free from root-disease infection were removed by cutting through the tap-root at one foot below ground level. Trees affected by, or adjacent to, disease-affected trees, had their tap-roots and laterals completely removed.

Block	Acreage	Stand per acre		
		1935	1936	1937
17 A	10 acres	180	165	125
17 D. N.	9 „	360	240	150
19	62 „	180	165	140
24	30 „	180	150	125

No serious storm damage was recorded during the year; trees affected by root disease were removed on routine rounds of inspection.

9. ROADS, BRIDGES AND DRAINS

Roads

424 chains of roads were metalled and sanded, and all roads on the Station are now in good order. A new road was cut for 45 chains along the western side of the Station. This facilitates transport of labour and materials to these clearings and gives easy access for visitors.

Bridges

Owing to a number of new areas coming under the knife, it was necessary to put out a number of tappers' bridges. These bridges are *chengal* and should last for many years.

Drains

Normal upkeep work on the main drainage system was carried out twice during the year. It was necessary to revet the sides of the main outlet drains in several places, where these had been damaged by the torrential rains in October—November.

Numerous hill-foot drains had to be cut in Bls. 32 and 33, as it was deemed essential to get a 100% stand for budding, and therefore damp areas had to be completely dried up.

Now that the new road along the western boundaries of the new areas, Bls. 30, 31, 32, and 33, is completed, it will probably be necessary to cut a main outlet through Forest Reserve land to facilitate the flow of water from the drains in these areas.

The anti-malarial system is regularly upkeep and is proving very satisfactory.

10. TERRACING, SILT PITTING AND BUNDING

Repairs to terraces were carried out on the hill areas in Blocks 19 and 24. Owing to the complete loss of the leguminous cover crops, it has been found necessary to establish indigenous covers, and cuttings of several species that grow in our reserve have been planted between terraces. The fern *Nephrolepis biserrata* has also been used for this purpose and is becoming well-established. It is anticipated that future repair work on terraces in this area will be negligible.

In Block 27, which is hilly land, an experimental area of 50 acres has supervision paths and plot boundaries at intervals of two chains from north and south and from east and west. Considerable erosion has occurred on these paths, owing to the timber having rotted away, and it was necessary to make bunds to stop wash. Owing to the heavy rains experienced at the end of the year, this work had to be temporarily suspended, as the heavy rains broke the bunds before they had had time to harden up. It will be continued early next year and *Desmodium ovalifolium* will be planted on the bunds.

In Blocks 32 and 33 lining was rectangular, and as it was anticipated that some lateral wash might occur along the planting rows, silt pits and bunds were cut between each pair of plants, and *Desmodium ovalifolium* was established on the bunds. This has become very well established and little erosion has taken place so far.

11. COVER CROPS

In the older rubber areas the leguminous covers, both bushes and creepers, are dying off, and an effort has been made to regenerate them by applying a cover-crop fertilizer.

Slashing of natural covers is done on certain areas to 3 ft. at regular six-monthly intervals, whilst on other areas, slashing is done to 4 ft. when necessary.

In experimental areas under indigenous covers selective elimination of different species is done. On other areas, where indigenous covers are maintained as part of the routine cultivation, undesirable species, such as bracken and stagmoss, are taken out.

Block 19

Before this Block was brought into tapping in 1937, the cover crops, *Centrosema pubescens* and *Pueraria javanica*, were pulled back 2 ft. on either side of the trees along the contours. An experiment consisting of spraying the encroaching tendrils of the covers on two edges of the strips with a one-per-cent solution of sodium arsenite was carried out.

This method demonstrated that it was possible to reduce weeding costs by increasing the intervals between weeding rounds.

Block 24

A small area in this field, in which bracken and stagmoss had been kept for demonstration purposes, was used to test chemical sprays. Bracken was slashed and ten days later it was sprayed with a one-per-cent. solution of sodium arsenate. This proved very effective in killing bracken, and it was possible to take the area into the normal weeding round, with no appreciable increase in costs.

The main problem confronting anyone carrying out such work is that of water-supply, for mixing up the solution. If water is easily obtainable the cost of such work should not exceed \$2.50 per acre. This sodium arsenite spray is very effective in killing out *Axonopus compressus* or "carpet grass."

Points to note in connection with this work are:—

- (a) that spraying should be done when conditions are likely to be dry; spraying should not be done in the very dry months owing to danger from fire;
- (b) hand-weeding or *tajah*-weeding of the area should not be done for about one month to six weeks after spraying, so that the chemical spray has plenty of time to penetrate to the tips of all the roots. If weeding is done too early the grass will come up again luxuriantly and all the initial expenditure will be lost.

Owing to slashing and dieback, the stand of natural covers is gradually diminishing annually.

Desmodium ovalifolium is establishing well on all the new areas and, being a non-climber, it appears to be a most suitable cover.

Broadcasting of leguminous cover-crop seeds as a method of establishment has given very poor results in germination. When the seed was dibbled in excellent results were obtained.

The cover *Dolichos biflorus* was established from seed in nurseries, in the open and under shade and grew well at first but later died out.

Crotalaria anagyroides and *Tephrosia candida* were established from seed in Block 4 nursery and in Block 20.

Cuttings of "Rorako" (*Ormocarpum Sennoides* Leguminosae), planted in Block 23A, have not grown well. It would appear that this species is not well-suited to the dry sandy soil of the station.

12. RUBBER UNDER INDIGENOUS COVERS—BLOCK 11

Owing to the modified system of slashing now in use, whereby only the fern is slashed low every six months, the natural bushy

growths are regenerating well. Since the fern has been controlled no trouble from mouldy rot has been recorded.

In the uncontrolled (unslashed) area, the natural growths are thinning gradually owing to the heavy shade; this is especially noticeable in the more densely planted area (180 trees per acre).

During the very dry spell experienced in June, July and August the crop yields in the cleaned-up (clean-weeded) strips dropped below those of the two areas under natural cover, for the first time.

This indicates the tendency of the soil in the natural-cover areas to remain cool and moist, and thereby to maintain a more constant yield from the trees, whereas in the clean-cleared plots the effect of the drought was very pronounced.

Termite attacks occurred in both natural-cover areas.

Yields are as follows: (Normal seedling rubber aged 9 years)

January—December 1937

Cleaned-up area	...	22' × 11'	673 lb. per acre per annum
Cleaned-up area	...	22' × 22'	396 lb. per acre per annum
Slashed controlled	...	22' × 11'	623 lb. per acre per annum
Slashed controlled	...	22' × 22'	390 lb. per acre per annum
Unslashed uncontrolled		22' × 11'	589 lb. per acre per annum
Unslashed uncontrolled		22' × 22'	391 lb. per acre per annum

It must be remembered that this is not a replicated experiment, but a "demonstration" with a single plot for each treatment, so that the recorded yields may not be regarded as accurate measure of the relative effects of the treatments. They are only records of the actual yields obtained from the plots, involving an unknown experimental error.

13. SOIL-EROSION EXPERIMENT. 4 ACRES

Annual manuring of the covers on this area was carried out with four phosphatic fertilisers (Annual Report Expt. Station 1936. para. 6).

The growth of the *Desmodium ovalifolium* established under shade is good.

14. CULTIVATION

The work of alternate-monthly digging and forking of 8 ft. rings round plants up to three years is still being continued, with beneficial results.

Nephrolepis biserata (fern) which was getting too tall and dense in Blocks 18, 19, 22 and 24 swampy areas, was slashed low, and will be cut back now at regular intervals, as all these fields have come into tapping.

Block 19. Cultivation Experiment (Soils Division) 9 acres

Digging in Grasses and covers was performed according to schedule twice during the year.

Girth measurements were taken and results will be published by the Soils Division.

On an area of one acre of peaty land in the swamp the fern was removed, and *Desmodium ovalifolium* was established as a demonstration area.

Block 25. 8 acres Cover Crop and Clean-Weeding Experiment

Regular rounds of slashing to 4 ft. were carried out, and measurements were taken. The Block is to come under the knife from January 1st, 1938.

15. PESTS AND DISEASES

Oidium Hevea

Sporadic cases of *Oidium Heveae* were noted, and dusting with sulphur was carried out during the wintering season.

A new sulphur-dusting motor machine was obtained from Ceylon; this machine is much lighter than any type previously tested by us. It throws the dust up well, and no mechanical trouble was experienced during its trial. The cost of the machine landed in Malaya was approximately \$400.

Leaf-attacks by red spiders, mites and *Thrips* spp. were noted on the younger areas, but the attacks were not serious enough to necessitate dusting being carried out.

Caterpillars (Achaea, Tiracola and Prodenia spp.)

No large-scale attacks occurred.

Cockchafer Grub (Psilopholis Grandis)

No attacks from this pest occurred.

Rat Damage

No signs of rat damage to plants were seen in the newly-felled and planted area Block 32 (18 acres), but in Block 33, also newly-felled, considerable damage has been caused by these vermin.

Painting the stems of the young plants and of the basket-plant supplies with a proprietary mixture "Bandite Tanglefoot" proved effective, and later losses were few. It should be noted that this Bandite Tanglefoot was old stock that had been open in store for some time.

Previously when this mixture was applied, considerable scorching of the stems of the plants occurred, which might be owing to the presence of carbon bisulphide in the mixture, when chemical had evaporated by the time the preparation was used for this clearing.

Mr. Beeley, the Pathologist, has issued a prescription similar to Bandite Tanglefoot which does not contain carbon bisulphide and this should be safer to apply.

Where circular wire-guards are used, but are not fully protective, the Bandite Tanglefoot may be applied on strips of paper tied round the upper portion of the guards.

Giant Snail

Considerable trouble from this pest was experienced in nurseries and gardens. Arsenical baits proved ineffective but later an experiment was carried out by Mr. Beeley using baits consisting of Meta fuel or calcium arsenate mixed with bran, and these baits proved most effective.

Results of the test will be published by the Pathological Division (see *J.R.R.I.M.* Vol. 8, No. 2, January, 1938).

Root Disease

Regular rounds of routine inspection and treatment were carried out in all Blocks. The treatment is the same as that recommended in the Annual Report, Experiment Station, 1934.

Details of work carried out are as follows:—

Disease	Trees treated	Trees removed	Total
<i>Fomes lignosus</i> ...	900	351	1,251
<i>Ganoderma pseudoferreum</i> ...	75	56	131
<i>Fomes noxius</i> ...	21	13	34
<i>Ustulina zonata</i> ...	12	4	16
Termites (White ants)	2,847	376	3,223
Pink disease ...	1,029	—	1,029
	4,884	800	5,684

Termites (White Ants)

The standard treatment with Cymag and sodium silicofluoride was carried out during the year, but, in addition, sections of fields were also treated by the newly developed "trail-injection" method, in which poison dusts are blown into the earth-runs on the trees.

This method, which relies upon the termites to carry the poison to the central nest, is naturally cheaper from a labour point of view than the method employed with the standard treatment, where the earth at the base of the tree must be opened up all round and the tunnels exposed.

Details of the materials used and results obtained are given in the report of the Pathological Division.

Pink Disease (Corticium salmonicolor)

Sporadic attacks of trees near the jungle edges were noticed, but these yielded to treatment with the recommended mixture of asphaltum and kerosene with 10 per cent Brunolinum. There were no signs of any one series of trees or clones being more susceptible than others to attack from this disease.

Mouldy Rot

No signs of this disease were recorded during the year. Slashing of the fern in the indigenous-cover areas has permitted a free passage of air, and more rapid drying of the tapping panels after rain.

Canker of Unknown Origin

Another tree in Block 10 has become affected by this disease. The similarity to lightning damage is very marked in this instance.

16. JUNGLE PLOTS A AND B. (10 ACRES SEED GARDENS OF *Hevea Spruciana*)

Monthly weeding is carried out in these areas, and seed is collected when seen. The seed, after collection, is being established in the main nursery, and will be used for planting an area of swampy land in Block 18 during 1938.

Termites are still troublesome in some areas, but it is hoped that treatment with white arsenic powder will effectively deal with these pests.

17. WEEDING

As stated above, alternate-monthly weeding and forking are done in 8 ft. circles round young plants up to three years of age.

Over the remainder of the area weeding is done bi-monthly or quarterly, the covers being kept clear of the trees to allow access for tapping.

On the older indigenous-cover areas it has been found that, owing to weeding and slashing, die-back of covers is noticeable and the 6 ft. clean-weeded strips are widening to 8 ft.; signs of

erosion are to be seen on the edges of the terraces. Weeding is now being done only from the back of the terraces to the rubber trees and it is hoped that natural covers will regenerate, and arrest this erosion.

All wild creepers and noxious growths are eradicated on sight on the new clearings, and selection and slashing are carried out when required. Slashing of covers and natural growths is never done during a dry spell or just after budding operations have been carried out.

Costs of weeding in natural-cover areas are higher than for those under legumes. This increased cost is owing to the selection and eradication of undesirable growths and to the regular side-pruning of the covers to stop them overshadowing the rubber trees.

Block 27, Leguminous bushy covers, creepers, and natural growths

Separate costs are kept for each treatment and these figures are available at the Station Office for the information of visitors.

Lalang

Patrols for the eradication of lalang are employed monthly in the areas under indigenous covers Bls. 28, 29, 30, 31, 32, 33, and after the first year, inspections are carried out at quarterly intervals. Young sporadic lalang, if found on other parts of the Station, is dealt with by the weeding gangs.

Slashing Building-Site Area

The compounds and building sites are slashed monthly. Slashing of drain edges in the anti-malarial areas is carried out whenever necessary.

18. BUDGRAFTING

Normal upkeep pruning rounds were carried out. Further budding was done in the following fields:

Block 5A—(1.8 acres Old Elephant Belt)

In this field budding was carried out with material from hand-pollinated crosses and high-yielding seedlings from Bls. 2, 14 E1, and 17D North.

Block 30—(40 acres)

This field was divided into 100 plots; budding was done with material from new R.R.I. Clones Nos. 500 to 522 inclusive, with clone Pilmoor B. 84 as control.

In this area, where no burning was done, the growth of the natural covers was excellent; these were slashed to 4 ft. before budding.

Block 31—(40 acres) Manuring Experiment on Buddings

This field is divided into 36 plots, for six treatments with six replications. Manuring was carried out from the start of planting.

The trees are now nearly two years old and have been budded, each plot being sub-divided into five strips, and five clones were budded across the field from east to west, the clones used being Tjirandji 1, Prang Besar 86, Pilmoor B. 84, Pilmoor D. 65 and Bodjong Datar 4.

The stand has been adjusted to 180 trees per plot.

19. HAND-POLLINATION

A series of hand-pollinations between a number of different clones was carried out by Mr. C. C. T. Sharp of the Botanical Division, in Blocks 5, 15, 18, 20 and 21.

A large, fenced nursery was prepared on the building site, for the establishment of the seedlings.

All seeds were first germinated in prepared soil in baskets in a rat-proof cage, and were later transferred to the nursery beds where they will remain for one year before transplanting to Blocks 32 and 33.

20. TAPPING EXPERIMENTS (Botanical Division)

Full details of tapping experiments in progress on experimental blocks under the control of the Botanical Division will be found in the report of that Division and therefore they are mentioned only briefly here.

Block 5

Boundary-row trees of all plots in this block, four plots of each of the following clones, A.V.R.O.S. 49, 50, 152, B.D. 5, Tj. 1, P.B. 23 and 186, and Pilmoor B. 84 and A. 44, are being utilised for an experiment to compare the effect on yield, of commencing tapping at different tapping heights on a single half-circumference cut and simultaneous tapping on two cuts on half-circumference on opposite sides of the tree. This experiment has been in progress for three years. Normal tapping on half-circumference is done on the main experimental plots and individual plot yields are recorded for each tapping day.

Block 6

The guard-row trees in this block, Manuring Experiment on Seedlings, Soils Division, are being used by the Botanical Division

for a small-scale experiment to compare normal tapping on half-circumference with tapping simultaneously on both sides of the tree (a modification of the so-called Sunderland system of tapping) and tapping on the full-circumference of the tree every fourth day. This experiment has been in progress since August 1935.

Block 6—Manuring Experiments, Soils Division

This Block was tapped on the A/D system and collection was done with separate marked buckets for each plot until the 30th September 1937.

From 1st October 1937, individual tree cup-coagulation was carried out until 31.12.37, in order to obtain a series of yield records for comparison by the Statistician, of the two methods of yield-recording.

Owing to the two experiments *i.e.* boundary-rows and main plots, both being on cup-coagulation, it was arranged during October—December 1937 that the boundary-row trees after tapping had a blue dye mixed with the formic acid solution put in the cups, so that the coagulated samples were blue and were not collected at the same time as the white centre-plot samples.

Block 17D (North)

This Block is planted with a collection of families of clonal seedlings. Test-tapping for a period of ten days was repeated in June 1937 for the purpose of selection and thinning out.

Block 23 (29 acres)

Three systems of tapping are employed in this field:

System I. Two cuts on opposite sides of the trees at 40 inches and 20 inches respectively. Tapping is carried out third-daily for six months, and then the trees are rested for six months.

System II. Single half-spiral cut at 20 inches; tapped A/D; no rest-period.

System III. Single half-spiral cut at 20 inches tapped daily, alternate-monthly.

Latex from these systems is used by the Chemical Division.

21. ROUTINE TAPPING

During the year the Blocks shown in the following statement "Details of Fields in Tapping" were regularly tapped. The initial height of the tapping cuts was 20 inches from ground for seedlings, and 40 inches from the union for buddings. During

DETAILS OF FIELDS IN TAPPING

<i>Block</i>	<i>Acreage</i>	<i>Planting Distance</i>	<i>Material</i>	<i>System of Tapping</i>	<i>Method of Latex Collection.</i>
2	30	30' x 30'	Collection of seedlings from Ceylon, Malaya and Java	Left half-spiral A/D near ground changed to 30" on 1/7/37	Part cup-coagulation, part latex collected and bulked
3	9.25	20' x 30'	Buddings made from hand-pollinated crosses planted in B1.4A	Left half-spiral opened at 20" from union	Cup-coagulation of individual trees
4 A	10.00	20' x 20'	Hand-pollinated crosses made on Pilmoor Estate 1929	Left half-spiral near ground. Changed over to 30" on 1/7/37	Cup-coagulation
4 C	2.5	20' x 20'	Clonal seedlings and stock experiment. Buddings and Seedlings (Twins).	Left half-spiral at 36" A/D	Cup-coagulation
5	40	20' x 20'	Clone Trial with 9 Clones. A. 44 B. 84, B.D. 5, Tj. 1, A.V.R.O.S. 49 P.B. 186 " 23 " 152 replicated 4 times	Left half-spiral at 40". A/D	Latex collected from each plot separately, made into sheet and yields recorded for each plot
6	40	22' x 22'	Manurial Trial Plot 6 treatments replicated 6 times. 36 plots in all. Unselected seedlings	Plots sub-divided. Half on left half-spiral at 20". Half on Basel V at 20". Both changed over to 30" on 1/7/37. A/D	Latex collected from each plot separately from 1-1-37. Individual tree cup-coagulation from 1-10-37 to 31-12-37

Details of Fields in Tapping—(Contd.)

Block	Acreage	Planting Distance	Material	System of Tapping	Method of Latex Collection.
7	10	22' x 22'	Unselected seedlings	Left half-spiral near ground, changed over to 30" on 1-9-'37. A/D	Latex collected separately from each treatment, <i>i.e.</i> , clean bushy covers, and low covers
8	10	22' x 22'	Unselected seedlings, with 200 bud-dings made from high-yielding B/B Trees	Seedlings: left half-spiral at 20" changed over to 30" on 1-9-'37. Buddings: at 40" A/D	Latex collected separately from each treatment, <i>i.e.</i> , clean, bushy covers and low covers. Buddings: individual cup-coagulation
9	8	22' x 22'	Unselected seedlings. Half area clean-cleared Half area timber un-cleared	Left half-spiral near ground level, changed over to 30" on 1-9-'37. A/D	Latex from each half collected separately
11	10	(5ac. 22' x 11') (5- 22' x 22')	Seedlings grown with indigenous covers	Left half-spiral near ground. A/D	Latex collected separately from each treatment, and planting distance
13 B	2.5	22' x 22'	Unselected seedlings	Left half-spiral at ground level. A/D	Cup-coagulation to 31-1-37, after that, latex bulked
14 A & B	40	20' x 20'	Buddings from hand-pollinated crosses	Left half-spiral A/D	Cup coagulation

Details of Fields in Tapping—(Contd.)

Block	Acreage	Planting Distance	Material	System of Tapping	Method of Latex Collection.
14 C & D	40	Density-of-planting $\left\{ \begin{array}{l} 10' \times 10' \\ \text{to} \\ 30' \times 30' \end{array} \right.$	A.V.R.O.S. 50	Left half-spiral A/D	Collection by plots in separate buckets
14 E, 1	5	20' x 20'	Seedlings	Left half-spiral A/D	Cup coagulation
14 E, 2	9	20' x 20'	Seedlings and buddings	Left half-spiral A/D	Cup coagulation
14 F	1	22' x 22'	Seedlings	Left half-spiral A/D	Latex collected and bulked
15	63	20' x 20'	Buddings. New clones	Left half-spiral A/D	Cup coagulation
16	40	20' x 20'	Hand-pollinated crosses and controls	Left half-spiral A/D	Part cup-coagulation, part latex collection
17 A	10	22' x 11'	Buddings and seedlings	Left half-spiral A/D at 22" and 40"	Cup coagulation
17 C	1	22' x 11'	Buddings A.V. 50 and D. 65.	Left half-spiral A/D	Latex from each clone collected separately 1-5-37
17 D (South)	9	22' x 11'	Buddings and seedlings	Left half-spiral A/D	Cup coagulation
19	53	22' x 11'	Buddings B.D. 5	Left half-spiral A/D	Latex collected 1-1-37
21	25	22' x 22'	Polyclone buddings of 7 clones.	Left half-spiral A/D	Cup coagulation
23	29	22' x 22'	Seedlings	Various tapping systems	Latex collected separately from each treatment
24	30	22' x 11'	Buddings B.D. 5	Left half-spiral A/D	Latex collected
25	15	18' x 18'	Clonal seeds and buddings.	Left half-spiral A/D	Cup coagulation

N.B.—Buddings all opened at 40 inches from union unless otherwise stated, and seedlings at 20 inches from the ground.

Average rate of bark-removal over the year was 7. inches.

the year a change to a new panel at 30 inches was made in a number of the blocks containing seedling material. Additional trees that reached the required standard of girth were brought into tapping on 1st July 1937.

Total area tapped during the year 530.5 acres.

Total Crop harvested for 1937—187,094 lb.

The Standard of Production permitted by the Controller of Rubber for 1937 was 146,972 lbs.

The following are the details of late tapping, wash-outs etc.

No Tapping	Late Tapping	Rain interfered
11 days	21 days	6 days

Cup-sample weighing, and distribution and collection of sample-wires and labels, takes up a considerable amount of time and labour. There are over 20,000 samples a month to be weighed and recorded; this work is done chiefly by junior staff of the Botanical Division resident on the Station.

22 CURING

Pan-sheet is still made from all Blocks, where individual plot- or clone-collection is made.

Latex from Bls. 19 and 24, B.D. 5 Mono-clone, is bulked in the tanks. Standard sheet of $1\frac{1}{2}$ D.R.C. is turned out on the F. E. Co.'s Battery.

Samples of 50 c.c. each are taken from each individual plot in Block 5; these samples are cured and despatched to the Chemical Division. Some trouble was experienced from oxidation of the upper portions of the coagulum in the pans, with rubber from certain clones. Sodium bi-sulphite was added to this latex and the trouble was stopped.

Sample sheets from seedling rubber and from buddings tapped on various systems are despatched to the Chemical Division.

A small percentage of our cup samples are milled to form crepe, as these are required for Botanical Division experiments. The remainder of the cup samples are sold in bulk locally.

A forward contract for two tons No. 1 R.S.S. per month was secured for the whole of 1937 at $37\frac{1}{2}$ cents per lb. Delivery of the unpacked sheet was made at a godown in Kuala Lumpur.

The large kampong-type smoke-house and the small Devon-type house are functioning very satisfactorily. Good sheet is turned out of the former in five days and in four days from the latter.

An experimental tunnel-type smoke-house, with portable above-ground fire-box, has been erected and is on test, under the supervision of Dr. Rhodes and Mr. Piddlesden of the Chemical Division. Results to-date are fairly encouraging.

23. MEASUREMENTS

Girth measurements were taken during the year by the junior staff of the Botanical and Soils Divisions over the following Blocks :—

Blocks 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, (Cultivation Experiment only), 20, 21, 22, 23 (Manuring Experiment only) & 25.

24. SPECIAL WORK

Scaffoldings were erected in Blocks 5, 15 (North), 17A, and 20 for hand-pollination work.

Leaf-sampling was done by the Soils Division in Bl. 5 (buddings) and Bl. 6 (seedlings and manuring experiment).

Clonal seed was collected, packed and despatched for use on experimental areas on estates, under the auspices of the R.R.I.

25. MEDICAL AND HEALTH

The health of the staff and labourers on the Station was excellent during the year. Special brush-oiling continues to be used efficiently.

The firm of Drs. Cameron & Mackintosh continued to act as our Visiting Medical Officers and my thanks are due to them for their assistance during the year.

A request was received from the Medical Officer of a large group of estates near Tampin for a demonstration of our special brush-oiling methods. The demonstration was carried out and the apparatus was lent to him for a large-scale test. A letter has since been received commenting favourably on the considerable saving in oil and labour that was achieved during the test.

Despite the fact that over 50 coolies were newly engaged for work on the Station, the average spleen-rate for the year was as follows :

Men	...	...	2 per cent
Women	...	...	.07 " "
Children	...	...	2 " "

There were only three cases of malaria recorded during the year.

26. RAINFALL

The rainfall recorded for the year was 101.43 inches.

27. BUILDINGS AND MACHINERY

All buildings and machinery are in a good state of repair and are fully covered by insurance.

New Buildings

A new bungalow was erected for the Assistant Manager, on the hill at the southern end of the Station.

A small bungalow of concrete, with tiled roof, was erected for the Asiatic Rubber Instructor stationed here, and a similar bungalow was constructed for the use of an additional Botanical Division laboratory assistant sent to reside at the Station.

A new concrete Chinese kongsi was erected early in the year; this is now being used to accommodate Tamil bachelors, since the departure of the Chinese, who gave notice and left the Station on the 1st November 1937.

The hostel and the bungalow of one of the Malay laboratory assistants have had essential repairs carried out.

It was envisaged that a further set of new lines would be required in 1938, and as these will occupy the site of the creche, this was pulled down and re-erected near the estate dispensary.

The existing bachelor lines which were of the back-to-back type were condemned by the Labour Department. These have now been remodelled at a nominal cost to accommodate the large families.

Machinery

A new sulphur-dusting motor machine was received from the agents of the Colombo Commercial Company. This machine has proved fairly satisfactory on trial and is much lighter than any of our other machines. It could be improved by fitting an agitator in the base of the hopper to give a more even flow of sulphur dust to the funnel.

A motor dusting machine was made and supplied to the Station by the local Government Factory. It is feared this machine will be of use only where estates are well-roaded and where it can be pulled round by coolies or by a lorry. It is far too heavy to be hand-carried amongst the rubber trees.

Water-Supply

The catchment dam was thoroughly cleaned out, and repairs to the pipe line were affected where necessary. A new 4,000-gallon water tank and tower has been installed at the factory.

Electric Light Plant

The 5 H.P. Petter electric lighting engine and plant, used as a standby for our larger plant, was transferred to the Assistant Manager's bungalow. This bungalow thus now has its own power-plant for lighting. This procedure was found to be more

economical than to connect this bungalow to the main power-supply for the rest of the quarters on the Station.

28. CORRESPONDENCE

Many letters were received during the year dealing with general planting practice. Where these letters dealt with technical details, they were passed on to the Division of the Institute concerned. Normal planting questions were answered from this Office.

29. HISTORY FILE AND COST CARDS

These were kept up-to-date, and are available for inspection by visitors.

30. STAFF

The European Staff on the Station during the year was as follows:—

Manager	...	...	H. W. Foston
Asst. Manager	...	...	T. N. Dickson
Assistant	...	...	R. F. Harley (4 months)

The Director, with the approval of the Board, decided to engage a permanent Assistant for the Station. Applications were called for in the Press, and candidates were interviewed in London, by a special sub-committee of the London Advisory Committee. Mr. R. F. Harley was chosen and joined the Station Staff for duty on the 28th August 1937.

The Asiatic Staff of and attached to the Station is as follows:—

<i>Experiment Station Staff</i>	<i>Divisional Staff attached to the Station for duty</i>
1 Chief clerk	5 Botanical Division laboratory
1 Typing clerk	assistants.
1 Dresser	1 Pathology Division laboratory
1 Tapping conductor	assistant.
1 Factory conductor	1 Chemical Division laboratory
1 Field conductor	assistant.
	1 Asiatic Rubber Instructor

The number of labourers on the check-roll varied between 213 at the beginning of the year and 243 at the end.

31. GENERAL

During the year under review a total of 568 people signed the visitors' book at the Station. Visits were paid by members of

the Incorporated Society of Planters from the following Branches: Kajang, Nilai-Labu, Bahau, Rantau-Port Dickson, Kuala Lumpur and Tanjong Malim.

Visits were received from Research Officers from the Dutch East Indies and other countries. Dr. Cramer, Mr. J. Grantham (formerly of H.A.P.M., Sumatra), Mr. Van den Beele, (Adviser on Agriculture to the Belgian Government) were among those taken round the Station. It was pleasing to meet and discuss planting topics with numerous planters from Ceylon. A considerable number of directors of companies, from England, France, Belgium and Holland visited the Station.

A noticeable feature this year was the number of visits paid to the Station by Malay small-holders, under the auspices of the Department of Agriculture. Visits were also paid by students (Malay, Chinese and Indian) from the School of Agriculture, Malaya, at Serdang. Indian, Chinese, and Japanese visitors were well up to last year's total.

Instruction in budgrafting, pest and disease work, tapping and field work was given to over 50 conductors. Two Europeans attended a course of instruction for 14 days. Newly-appointed Asiatic Rubber Instructors, before being appointed to their Stations, were given a month's practical course on the Experiment Station.

My thanks are due to the General Manager, Kepong (Malay) Rubber Co., Ltd. and to Mr. C. J. Arnold of Edinburgh Estate, Kepong, for their assistance during the year. The latter gentleman took great pains to help instruct visiting conductors in root-disease work in old rubber areas.

Labour wage-rates were raised as from 1st January, 1937, to 50 cts. for Tamil males and 40 cts. for females.

In conclusion I wish to thank the Staff, both European and Asiatic, for their assistance during the year under review.

H. W. FOSTON

Manager

Sungei Buloh

14th February, 1938.

ANNUAL REPORT

LONDON ADVISORY COMMITTEE FOR RUBBER RESEARCH (CEYLON AND MALAYA)

The Committee and Technical Sub-Committee held three meetings during the year.

The Committee regret to report that Mr. H. E. Miller and Mr. W. J. Gallagher, both of whom had rendered very valuable services for several years, were unable to continue their membership of the Committee. Messrs. Eric Macfadyen and J. L. Milne were appointed by the Rubber Growers' Association to replace them as representatives of rubber planting interests in Malaya.

Meetings of the Committee and Technical Sub-Committee were attended by the following visitors from Ceylon and Malaya:—

Rubber Research Institute, Malaya

Lieut. Col. B. J. Eaton—Late Director

Mr. J. D. Hastings—Chemist

Mr. H. Fairfield Smith—Statistician

Rubber Research Scheme, Ceylon

Mr. I. L. Cameron—Board of Management

Mr. R. K. S. Murray—Botanist

Department of Agriculture, F.M.S.

Mr. G. H. Corbett

At the request of the Research Association of British Rubber Manufacturers Mr. Le Bras, a member of the research staff of the Institute Francais du Caoutchouc, spent a fortnight working in the Committee's laboratories where he was instructed in the technique of latex testing.

Several conferences were also held with Dr. Kraay, Superintendent of Rubber Investigations West Java Proefstation, at which details of the programme of work of the two organisations were discussed.

FINANCE

Contributions of £2,625 and £875 were received from the Rubber Research Institute, Malaya, and the Rubber Research Scheme, Ceylon, respectively towards the cost of the work of the Committee during the year 1937. The expenditure incurred amounted to £3,470.4.8d. and after allowing for reserve for plant and for liabilities outstanding, there was an unexpended balance of £900 at 31st December, 1937.

APPOINTMENT OF STAFF IN CEYLON AND MALAYA

At the request of the Director of the Rubber Research Institute, Malaya, steps were taken to select candidates for the following vacancies:—

Botanist
 Advisory Officer, Botanical Division
 Chemist
 Statistician
 Assistant at the Experiment Station.

An advertisement was also issued in the press in this country on behalf of the Ceylon Rubber Research Scheme inviting applications for the post of Geneticist to be submitted direct to the Chairman of the Board. The Committee were subsequently requested to interview and make the final selection from certain of the candidates regarded by the Board as the most suitable. It was, however, found that all the candidates concerned had accepted other appointments and the Committee were then asked to readvertise the post, receive the applications and submit a name for appointment by the Board. At the end of the year a selection was being made for the post.

STANDARDISATION OF RAW RUBBER

In 1936 the attention of the Committee was drawn by the Research Association of British Rubber Manufacturers to the difficulties experienced by certain manufacturers in obtaining uniform supplies of raw rubber and products suitable for their industrial requirements and the possibility of supplies of certified rubber being offered.

These difficulties were referred to a Sub-Committee which met on two occasions during the year. In view of the renewed interest being displayed in the subject by manufacturers in this country and the U.S.A., and the developments which are arising in connection with competitive synthetic products the sub-committee suggested to the Rubber Research Institute, Malaya, and to the Rubber Research Scheme, Ceylon, that further attention should be given in their programmes of work to the variability of raw rubber and to the possibility of obtaining uniform rubber from selected estates. As a result a scheme of investigation in continuation of the experiments on the variability of Ceylon estate rubber carried out in collaboration with the Committee some years ago has been approved by the Board of Management in Ceylon. The Director of the Rubber Research Institute, Malaya stated that some research on standardisation would be dealt with in the

programmes for 1938, but he pointed out that the cost of a systematic survey of the output of a large and representative selection of Malayan estates for not less than one year would be considerable and without the employment of additional staff could not be undertaken without giving up the whole of the existing work for the period of the enquiry. He asked that before submitting a proposal of this character to the Board he should be furnished with precise information as to the requirements of different types of consumers.

Arrangements were accordingly made for an agreed statement giving the data required to be prepared by manufacturers on the sub-committee in consultation with the Crude Rubber Committee of the American Chemical Society. This had not been received by the end of the year.

INVESTIGATIONS

Hitherto the work has consisted chiefly of *ad hoc* investigations dealing with the production and quality of latex and raw rubber but in view of the developments in the competition from synthetic materials, whose technical advantages over rubber depend upon fundamental differences in structure and chemical composition, it is considered desirable now to devote more attention to long range investigations such as the colloidal structure of latex and changes in the caoutchouc phase of rubber on keeping under different conditions. The investigations on latex have already given considerable information concerning the cause of creaming and the factors affecting the efficiency of the process. They have also added to the data available with regard to the effect of ammonia on latex and the treatment required in order to obtain from latex a rubber which does not readily absorb water and which is, therefore, of special value for the electrical industries.

The development of tests for determining the quality of latex referred to in the Report for 1936 has been stimulated by co-operation with the British Standards Institution and associated organisations. New tests for extraneous matter have been evolved and the tests previously suggested for stability and for dry rubber content have been modified and improved. A survey of the whole of the work carried out by the staff on the development of scientific tests for determining the quality of latex was given in a paper read by Mr. Davey before the London and Midland Sections of the Institution of the Rubber Industry. It is of interest to record that as a result of proposals made arising out of this work, after consultation with other interested organisations, cheap colour standards for latex are likely to become available to the trade shortly.

Research on the incorporation of bitumen in rubber by the scientific staff of the London Advisory Committee in association with the technical staff of the Limmer and Trinidad Lake Asphalt Company Ltd. was continued on behalf of the Technical Research Committee of the Rubber Growers' Association.

Experience with highway surfacing trials described in previous reports indicates that there is little apparent difference between a freshly laid bitumen carpet containing rubber and one without rubber, but in the course of time there appears to be less tendency for the carpet containing rubber to "flush-up" and become smooth. As "flushing up" of bitumen is due to its flow properties it was decided to broaden the research with a view to obtaining a more complete picture of the causes of these properties over a wide range of conditions. The results so far obtained have confirmed the previous conclusion regarding the value of small proportions of rubber in reducing the flow tendency of bitumen.

Complementary work on the roads has been continued and will be extended in 1938. While it is early to draw definite conclusions the evidence available on the use of bitumen/rubber compositions appears encouraging.

The use of latex-cement mixtures for flooring and other purposes is attracting considerable attention in Great Britain and a paper read by Mr. Wren before the London and West of England Sections of the Institution of the Rubber Industry in October and December respectively describing the work carried out on the subject during the last three years has been in considerable demand. Recent work on the subject has been devoted principally to formulating, by experimental trials, practical mixtures for use based on the principles evolved in the fundamental work previously carried out and in devising physical tests which will enable standards to be formulated for different qualities of material.

As in previous years, the staff in London co-operated with the chemists in the East in the examination of samples prepared in connection with experiments in Ceylon and Malaya. A list of the reports furnished on these investigations and on others initiated in the Committee's laboratories is given below. Further information as to the investigations completed and in progress during 1937 will be found in the technical appendix to this report.

CO-OPERATION WITH OTHER ORGANISATIONS

Mr. Martin continued to serve as a representative of the Research Association of British Rubber Manufacturers on the Joint Committee of that Association and the British Electrical Research Association dealing with the quality of ebonite. Trials arranged by the Joint Committee with samples of rubber prepared

in Malaya show that the ebonites with the least water absorption have the best electrical properties and *vice versa*.

Mr. Martin has also acted as representative of the Rubber Growers' Association on committees of the British Standards Institution appointed with a view to co-ordinating methods of testing rubber and latex to be employed in specifications for a variety of manufactured articles.

Throughout the year the Building Research Station has been kept informed of the progress of investigations on latex cement mixtures and the thanks of the Committee are due to the Association for a number of useful suggestions.

Patents

As in previous years, abstracts of English patent specifications in respect of inventions relating to processes for the preparation and/or utilisation of raw rubber and latex were made for the information of the Rubber Growers' Association, the Rubber Research Scheme (Ceylon) and the Rubber Research Institute (Malaya) and copies of specifications of special interest were obtained for the research organisations in the East.

In conjunction with the Rubber Producers' Research Association steps were taken to obtain English patents in connection with inventions arising out of the work of the staffs in London and in the East.

Applications Sealed during 1937

465,226—Organic Liquid Addition to Latex. (Communicated by the Rubber Research Institute of Malaya).

Complete Specifications Filed during 1937

30770/36—Rubber and Cement Mixtures.

Complete Specifications Accepted during 1937

474,651—Concentration of Latex by Creaming. (Communicated by the Rubber Research Institute of Malaya).

476,073—Stabilised Cream. (Communicated by the Rubber Research Institute of Malaya).

476,269—Brominated Rubber.

476,743—Preparation of Chlorinated Rubber.

Provisional Specifications Accepted during 1937

19543/36—Softened Rubber from Stearate Crumb. (Communicated by the Rubber Research Scheme, Ceylon).

REPORTS ON INVESTIGATIONS FORWARDED TO CEYLON AND MALAYA
DURING 1937

Creaming of Latex

Latex creamed with sulphonated lorol.

Purification of latex.

Microscopic study of creaming phenomena (two reports).

Preservation of Latex

Latex preserved with different amounts of ammonia.

Storage of latex under tropical conditions.

Latex preserved with different amounts of ammonia.

Latex (General)

Comparison of latex concentrated by evaporation and filtration.

Filtered latex.

Samples received from the Ceylon Rubber Research Scheme.

Purification of latex by treatment with proteolytic enzymes.

Investigations connected with the Preparation of Rubber

Chlorinated and brominated derivatives of rubber from latex.

Effect on quality of sun drying wet coagulum.

Low water absorption rubber.

The use of phenylhydrazine derivatives as softening agents
for rubber.

Miscellaneous

Miscellaneous investigations.

Examination of samples of Buna.

P. J. BURGESS

Chairman

J. A. NELSON

Secretary

Imperial Institute,

28th April, 1938.

TECHNICAL APPENDIX

TO THE ANNUAL REPORT OF THE LONDON ADVISORY COMMITTEE

Latex

(1) SPECIFICATION AND TESTING

The devising and development of tests for the quality of latex referred to in previous reports have been stimulated by the interest in the subject now displayed by the British Standards Institution in Great Britain and the Crude Rubber Committee in the U.S.A. The staff have co-operated with the former in formulating recommended methods of testing and most of the suggestions submitted on behalf of the Committee have been accepted. Tests for the determination of coagulum and other undesirable solids have been devised, and new information has been obtained from further work on colour and stability of liquid latex and on tensile strength and ageing properties of dried latex films.

Colour of Liquid Latex. The colour of latex is not an accurate measure of quality but the trade make a rough classification by colour when valuing latex and some time ago drew the attention of the Committee to the need for a cheap and simple set of standards for their purpose. The apparatus devised by the staff, and referred to in previous reports, has been in general use in the Committee's laboratories throughout the year and whilst it has not been possible to match the colour of every sample examined owing to the multiplicity of shades encountered a classification sufficiently accurate for practical purposes was always made.

The results obtained with the matching outfit were brought to the notice of the British Standards Institution who propose to reproduce the nine shades on a card, the colours being obtained by dispersing magnesium carbonate, cadmium sulphide and carbon black in a cellulose compound. It is anticipated that these colour cards will be available at a very low cost to all who are interested in the production and marketing of latex. Similar colour cards are already available as standards in the paint industry. Owing to the cellulose compound not being absolutely resistant to atmospheric influences these cards do not remain serviceable for more than two years, and this limitation would probably apply to the cards proposed for matching the colour of latex.

Stability. The apparatus devised and constructed in the Committee's workshops for the determination of stability has been redesigned, the chief alterations being (a) the apparatus is more

compact, (b) control of temperature of testing is more accurate and (c) the rate of stirring has been increased from 600 to 2,000 revs. per minute, thus reducing the time required for the test to approximately one fifth of that previously necessary. The experience gained during the year confirms the general utility of the test.

Previous experiments showed that in order to obtain reproducible results with this apparatus it is necessary to use the same supply of zinc oxide. It has now been found that samples of the same grade from different sources give fairly uniform results, but there is sufficient variation to necessitate carrying out comparative tests when using a fresh supply of zinc oxide.

Reference was made in last year's Report to stability tests using sodium silicofluoride as a coagulant. This may be regarded as typical of the chemicals used for the coagulation of preserved latex and may give different results from zinc oxide which does not coagulate latex unless stirred vigorously and which, therefore owes its effect chiefly to the mechanical action of stirring, although the chemical reaction between zinc oxide and ammonia has a marked effect on the result. Some experience has now been gained with other salts as coagulants and some of them such as magnesium chloride, calcium chloride, aluminium acetate and ammonium alum give promising results. So far no marked discrepancy has been observed between the results with chemical coagulants and those with zinc oxide, and since there is always the danger that chemical coagulants may be specific in their effect, the zinc oxide test is at present preferred.

Coagulum and other undesirable Solids. The terms of the Rubber Trade Association standard contract specify that latex should be free from extraneous matter, such as bark, leaves, etc., but however carefully latex is prepared it always contains a certain amount of inherent but undesirable solids which can be divided into two groups, *viz.*, coarse material such as coagulum and fine material consisting largely of inorganic matter. It is difficult to determine accurately the weight of this material when separated by the ordinary type of sieve and moreover the sieve cannot be cleaned satisfactorily. A modified sieve has, therefore, been evolved in which a weighed disc of stainless steel gauze is clamped between two rings, through which the latex is strained and the residue washed. The sieve is then dismantled and the disc and residue dried and reweighed.

The finely-divided material is determined by centrifuging a known volume of latex in accurately calibrated tubes in a standard centrifuge for a fixed period of time at a speed of 2,000 revs. per minute. The centrifuge tubes recently recommended by a

Committee of Public Analysts for the estimation of dirt in milk (*Analyst*, 1937, 62, 287) have been found to be suitable for this purpose.

The results of tests on a few samples of latex indicated that the coarse material generally forms less than 1 part per 1,000 of latex (by weight) and the finely divided sediment seldom exceeds 10 parts per 1,000 (by volume). The finely divided sediment is, of course, much less in latex concentrated by centrifuging than in other types.

Tensile Strength of Dried Latex. The determination of the tensile strength of dried latex films has been recommended as a test by some organisations and has been used tentatively by the London staff, who have now shown that the results are markedly affected by conditions such as the thoroughness of drying, rate of stretching of the test piece, and temperature of testing. It has also been shown that when the films are dry they rapidly become stronger at atmospheric temperature, presumably due to polymeric changes in the caoutchouc. At much higher temperatures they may become stronger for a time and then weaken. In these circumstances it is difficult to formulate testing conditions which will ensure reliable results. On the other hand the test is of some value because experiments indicate that it can be used to detect latex which has been treated by oxidising agents to promote a white colour and which usually gives a low tensile strength figure particularly on ageing.

(2) PRESERVATION

(a) *Bactericides*

Although ammonia is an excellent preservative for most purposes, there are some uses for which its pungent odour is objectionable and the R.R.I. has continued its search for a suitable substitute. New bactericides are frequently placed on the market, and as opportunity arises, samples are forwarded from London to the East for trial. This year those forwarded include Nipasin M, a range of organic thiocyanates, isothymol, chlor-iso-thymol, merthiolate and propyl and ethyl hydroxybenzoate, all of which proved to be either unsatisfactory or uneconomic. On the other hand a sample of latex has been received from the Rubber Research Institute treated with a little ammonia and sodium pentachlorophenate and the latex has remained in a fluid condition for about six months, although during this time a decline in stability has taken place. Sodium pentachlorophenate is regarded as a promising new preservative, but more experience is required before definite conclusions can be drawn.

(b) *Keeping Properties*

An examination of a sample of latex which had been stored in Ceylon for a year indicated that the latex had deteriorated as regards colour, stability, freedom from coagulum and mineral impurities and resistance to ageing, although apart from the bad colour the results still compared favourably with many commercial samples examined in the laboratories. A more comprehensive study of the keeping properties of latex both in Ceylon and in this country is now being made.

A series of samples of latex prepared with different amounts of ammonia (from 0.56 to 1.64 per cent) was also obtained from the Rubber Research Institute, Malaya, and examined periodically after storage in London in their original containers. After twelve months all showed reduced stability. It is unlikely that this deterioration is due to bacterial action as the samples with the largest and least ammonia contents showed the same reduction in stability. The effect is more probably due to hydrolysis by ammonia of the natural protein stabilising agent in latex, in which case it is possible that eventually the sample containing the most ammonia will be the least stable. The fact that the properties of ammonia-preserved latex change appreciably on keeping is of considerable practical importance and emphasises the undesirability from a technical point of view of keeping latex in stock for more than a few months although of course it will retain its liquid condition for years.

(3) CONCENTRATION

(a) *Evaporation*

An apparatus for the concentration of latex constructed by the staff in London was supplied to both the Rubber Research Institute of Malaya and the Ceylon Rubber Research Scheme for concentration trials. Both of these organisations confirm that it is possible to concentrate fresh latex in the apparatus without the aid of additional stabilising agents, the optimum concentration consistent with ease of handlings, being in the region of 68 per cent dry rubber content, but the general opinion is that the throughput of the apparatus is low and further, the loss of ammonia which takes place during the evaporation of the latex is a disadvantage. A new type of evaporator will be tested in London during the coming year.

(b) *Filtration*

Promising results of concentrating latex by filtration on a small scale were obtained by the Rubber Research Institute giving

rise to a request that the London staff would make enquiries as to the possibility of obtaining suitable filtering media for latex. Considerable assistance was given by the well known pottery firm, Messrs. Doulton and Co., who supplied a large variety of pottery ware for experimental purposes. It was found that the texture of the material suitable for the filtration of latex lay within a narrow range, and although it was possible to obtain fairly satisfactory results with a small apparatus, this was more difficult with larger apparatus. During the course of this work several mechanical devices were tried in order to prevent the formation of paste on the walls of the vessel, and also to increase the speed of filtration, but these difficulties were not overcome completely. Two small consignments of latex concentrated by the filtration of creamed latex and by evaporation were received from the Rubber Research Institute, who had found the viscosity of the evaporated latex to be much higher than that of the filtered latex, although substantially of the same dry rubber content. On examination in London a comparatively greater difference in viscosity was observed. The removal of the serum during filtration produced a latex having a low content of non-rubber substances, being of the order of 2 per cent based on the rubber. This has the effect of lowering the stability of the filtered latex in comparison with the evaporated latex. Such a latex would, however, doubtless have commercial possibilities if it could be produced on a large scale.

(c) *Creaming*

The Rubber Research Institute has investigated the creaming action on latex of a number of dispersing agents, and has discovered that a cream having a high dry rubber content can be obtained with sulphonated lorol provided that a relatively high concentration of the creaming agent is used. The substance is ineffective in an alkaline medium and despite the absence of ammonia or some similar substance the latex retains its stability for a considerable period. Tests on the latex in London confirmed that the retention of a large proportion of the sulphonated lorol in the latex has a protective influence and imparts a high stability, and that the latex is not easy to coagulate, except with organic liquids. It also appears to prevent effective adhesion of the rubber particles when the water phase is removed. For these reasons it was considered that the latex would be unsuitable for the manufacture of many articles from latex. Its suitability for other uses has, however, been confirmed but the high cost of creaming places the material at a serious disadvantage.

A process for the removal of water-soluble serum substances by the repeated creaming of latex is used commercially to obtain

rubber' suitable for the electrical industries. A sample of latex which had been creamed three times in Ceylon was examined in London and found to contain rather more nitrogen than that reported by other investigators. The difference is probably due to the fact indicated by experiments in London that old ammoniated latex can be more easily purified than fresh latex. The triple-creamed latex may nevertheless be of satisfactory quality where low water absorption is required.

(4) COLLOIDAL PROPERTIES

(a) *Creaming Phenomena*

Microscopic study of mixtures of latex and hydrophylic colloids showed that creaming agents have the distinctive property of aggregating the latex globules into clusters which are reversible on shaking the latex or on dilution of the creaming agent. The rate and degree of creaming was shown to be a function of the size of the clusters and the viscosity of the latex. Latex can be purified by repeated creaming and dilution with water but when it is creamed three or four times further creaming becomes difficult unless the latex is diluted to 30 per cent concentration or less, and moreover, the dry rubber content of the concentrate at this stage seldom exceeds 50 per cent, apparently due to some property which makes it difficult to obtain close packing of the clusters. A sample of triple-creamed latex from Ceylon was creamed 14 times in London and apparently the process could have been repeated indefinitely. The dry rubber content of the concentrate was always less than 50 per cent and the rubber from the purified latex still contained an appreciable amount of nitrogen, which could not be wholly due to the fact that the creaming agent employed contained some nitrogen. The cause of clustering, and the effect of repeated creaming on the chemical composition of latex and the packing of the clusters is to receive further attention.

(b) *Distribution of Non-rubber Substances*

When latex is allowed to separate into two layers by creaming it is possible to calculate the amount of any non-rubber substance associated with the caoutchouc from a determination of the amount present in the skim and in the original latex. Preliminary investigations indicate that the nitrogenous substances associated with the caoutchouc are reduced by chemical interaction with ammonia and that there is a marked decrease when latex is diluted to contain less than 10 per cent dry rubber. Acetone-soluble substances and their acid constituents are also reduced by dilution. Further studies are now being made to determine whether the

association of caoutchouc and non-rubber substances follows an absorption law.

A few parallel studies on the treatment of latex with enzymes as a step in removing constituents which have a detrimental effect on rubber used for electrical purposes have shown that trypsin at 30°C. and papain at 60°C. are equally effective in reducing the amount of nitrogenous substances associated with caoutchouc. The experiments also indicated that a preliminary hydrolysis of proteins by either enzymes or alkalis is a desirable step in the preparation of rubber for use in the electrical industries.

Rubber

(1) SOFTENED RUBBER

Considerable interest has been displayed in recent years in the softening of rubber by hydrazine compounds and a series of samples was prepared in Malaya with the object of investigating the effect produced on the rubber by adding phenylhydrazine hydrochloride to latex.

The samples were examined in London and demonstrated that soft rubber could be prepared by adding phenylhydrazine derivatives to latex but the poisonous character of the softening agent employed would prevent its use on a large scale.

It is well known that on exposure to the action of direct sunlight rubber becomes soft and, as a matter of interest, samples were obtained from the Rubber Research Institute with a view to determining whether rubber softened by this means is different in quality from that of commercial "softened rubber" prepared by heating in air. The sun-dried sheets were fairly uniform in colour but were sticky in places with varying plasticity values for different parts of the sheets. The rubber was not sufficiently soft to be classed as "softened" rubber, and gave consistently lower tensile strengths and had definitely poorer ageing properties than a control sample of sheet, suggesting that rubber softened by sunlight to the same extent as "softened rubber" would be inferior in quality.

(2) "LOW WATER-ABSORPTION" RUBBER

Previous experimental samples prepared at the Rubber Research Institute of Malaya by the proteolytic decomposition of the protein, having given promising results, a larger consignment was requested for distribution to manufacturers. The differences between the original small samples and the larger sample since received indicate that the method has features which may be difficult to control in practice. Simultaneously, with the

examination of the above samples, two samples prepared on the Goodyear estates in Sumatra, were also tested, opportunity being taken to use the hot water immersion method which is preferred in the U.S.A. They had a very low nitrogen content and a correspondingly low water absorption value.

(3) SYNTHETIC RUBBER—BUNA

Buna is the name given to the rubber-like products obtained in Germany by the polymerisation of butadiene. A number of different grades are being marketed differing in degree and mode of polymerisation, and in physical and chemical characteristics, each grade being manufactured to suit the industrial purpose for which it is intended to be used. At the time of the investigation some difficulty was experienced in obtaining appreciable amounts of the different grades, but sufficient of three varieties was obtained for a preliminary chemical examination, which showed that the samples of Buna consisted of a complex mixture of substances and that in one case the polymerised butadiene did not exceed 50 per cent of the material.

Commercial supplies of Buna are now available and will be tested when opportunity occurs.

(4) HALOGEN DERIVATIVES OF RUBBER FROM LATEX

A description was given in the last report of the preparation and properties of partially-halogenated derivatives of rubber from preserved latex. Samples prepared from fresh latex were subsequently received from the Rubber Research Institute and were under examination at the end of the year.

A method has now been devised for obtaining from preserved latex a more fully chlorinated rubber in the form of a white powder which is soluble in organic solvents. This appears to have similar properties to the chlorinated rubbers prepared from dry rubber which are used in varnish making.

Road Surfacing and Flooring Materials

(1) LATEX-CEMENT MIXTURES

A more detailed study was made of the microstructure of latex-cement mixtures, hydration processes involved during setting, methods of compounding and mechanical properties which were referred to in the report for 1936. Other investigations carried out were (a) a study of the effect of protective colloids and other substances on the properties of cement-latex compositions and the development of formulae for practical mixtures, (b) a preliminary examination of the relation between cement-latex binders

and various aggregates, (c) a preliminary study of the technique of application of cement-latex compositions as flooring, together with small-scale practical trials (including the refacing of worn stone steps), (d) the development of a series of mechanical tests to measure the physical characteristics of cement-latex mixtures, (e) the comparison of various cement-latex compositions with other flooring materials.

For practical processing it was found necessary to control (1) the period during which the mixture remained stable, (2) the viscosity, (3) the time required to set hard. This was found to be possible by using (1) stabilisers, such as casein, (2) materials which decrease viscosity such as crystalline sodium silicate and those which increase it, such as well known compounding ingredients and (3) substances which accelerate the set of the cement, such as lime. The nature of the finished product was found to be partly dependent on the quantities of stabilisers and cement-set accelerators used; with excess stabiliser a soft product was generally obtained; with excess accelerator a hard cementitious material resulted. Delayed coagulants also gave rise to rubbery products. It was found that increased quantities of water caused a reduction both in the tensile and compressive strength, whereas an increase in the proportion of rubber gave rise to greater tensile strength, but reduced the compressive strength. Vulcanising ingredients appeared to exert no appreciable effect on the mechanical properties but were thought to confer improved resistance to ageing. A number of mixtures which were satisfactory for use as binders with aggregates were eventually devised, details of which were published in the *Journal* of the Institution of the Rubber Industry.

Trials were made with various types of aggregate which were found to have marked effects on the properties of the finished mixtures. Soft flexible aggregates such as cork, asbestos, shredded waste rubber and wood chips generally gave good adhesion to a flexible binder and hard aggregates such as granite, marble, gravel and crushed cement were more suitable for use with a hard binder. In order to obtain mixtures which could be trowelled to a smooth finish it was necessary to use an aggregate with controlled proportions of different particle sizes.

During a discussion of the work with the Building Research Station it was pointed out that physical tests were necessary to obtain standards which would enable users to specify the quality required and also to compare the properties of cement-latex mixtures with those of well-known flooring materials with which they would have to compete. A comprehensive series of tests was, therefore, drawn up in co-operation with the Building Research

Station and so far the following have been developed; (1) tensile and compressive strength, (2) hardness, (3) coefficient of restitution, (4) water absorption, (5) contraction during setting and (6) ageing properties. Machines for determining tensile strength and coefficient of restitution had previously been constructed; a machine for measuring compressive strength which gives an autographite record of the stress-strain relationship during compression has since been built in the departmental workshops. Arrangements were also made for abrasion tests to be carried out in co-operation with Professor R. G. H. Clements in the Highways Laboratory of the City and Guilds (Eng.) College.

The results of the various tests show that commercial cement-latex mixtures possess properties similar to those of other flooring materials with the important advantage that their resilience can be increased to a value exceeding that of any other flooring material not containing rubber. The range in properties of the mixtures is very wide and by making simple adjustments in composition it is possible to obtain material nearly as hard as cement or softer than asphalt.

(2) RUBBER-ASPHALT MIXTURES

Preliminary work carried out in previous years showed that in some circumstances the addition of rubber to bitumen improved its properties and it was therefore considered desirable to make a detailed laboratory study of the subject. In this connection an investigation was made during the year of the effect of rubber on the properties of five typical classes of bitumen, viz. (1) a straight-run asphaltic bitumen, (2) a straight-run asphaltic bitumen in combination with Lake Asphalt, (3) "oily" bitumen, (4) a blown bitumen, and (5) an oil-fluxed Lake Asphalt. The best mixtures for the purpose of highway surfacing appeared to be those containing a proportion of blown bitumen. This is particularly interesting as, in non-rubber work, the use of any appreciable proportion of blown bitumen is regarded as unsound owing to the low ductility of the latter material and its general brittleness at low temperatures. When, however, the blown bitumen is blended with both straight-run bitumen and rubber, these disadvantages disappear and an extremely tough mixture results, having a good ductility over a wide temperature range.

Experience with highway surfacing trials has indicated that there is little apparent difference between a freshly-laid bitumen carpet containing rubber and one without, but in the course of time it is observed that there appears to be less tendency for the surface containing rubber to "flush-up" and become smooth. These surfaces should, therefore retain their non-skid characteristics for

a longer period than a bitumen surface without rubber. The "flushing-up" of bitumen is due to its flow-properties, and rubber is more likely to receive favourable consideration, therefore, because of its effect on flow-properties of bitumen than for any other reason.

In March it was decided to embark upon a more detailed study of the flow-properties of rubber/bitumen mixtures, and an extensive programme of work was drawn up. A special viscometer of the rotating cylinder type was constructed in order to determine the absolute viscosity of the materials over a wide range of atmospheric temperatures. From the results so far obtained it is apparent that none of the materials examined to date behaves as a true fluid. The departure from Newtonian laws appears to depend upon the rate at which the material is displaced. This makes the whole research extremely complicated, but gradually a complete picture is being prepared of the flow-properties of bitumens with varying proportions of rubber incorporated over a wide range of conditions. Earlier views are confirmed concerning the value of small proportions of rubber in reducing the flow-tendency of bitumens.

In addition to the laboratory work, the rubber/asphalt research was continued on a practical scale by the laying of eight further sections of road at Poole. These embrace mixtures embodying rubber in latex and crumb form, and recent inspections show that so far the trials are successful and there is every prospect that they will maintain their "non-skid" surface over a long period. At the close of the year arrangements were in hand for the laying of further trial sections in the London area during 1938. It is also of interest to note that the original section laid at Poole, Dorset, in 1935 is still in excellent condition.

G. MARTIN

Superintendent of Rubber Investigations

Imperial Institute,

28th April, 1938.

Publications

Publications of the Rubber Research Institute are issued in the following forms at prices stated at time of publication:

- (a) **Planting Manuals**—being articles of an instructional nature primarily for estates' use. These appear at irregular intervals.
- (b) **Bulletins**—being articles of special scientific interest printed and bound separately, appearing occasionally
- (c) **Journal**—being articles by officers of the Institute on current work, appearing at irregular intervals as information accumulates during the year
- (d) **Annual Reports** of the work of each Division during each year, with a summary by the Director R.R.I.
- (e) **Information Cards**—being concise precis of the processes of estate factory practice.

The following publications have been issued and copies can be obtained on application at the prices given against each:—

(a) PLANTING MANUALS

- No. 1 "Guide to the Preparation of Plantation Rubber"
by B. J. Eaton (published August 1928) ... \$2.00
- No. 2 "Budding of Hevea in Modern Plantation Practice"
by F. Summers (published September 1928) (out of print)
- No. 3 "Plantation Sheet Rubber Manufacture"
by R. O. Bishop (published February 1932) ... \$2.00
- No. 4 "Latex Preservation and Shipment"
by R. O. Bishop and R. G. Fullerton
(published July 1932) ... \$2.00
- No. 5 "The History and Description of Clones of Hevea Brasiliensis"
by C. E. T. Mann and C. C. T. Sharp
(published August 1933) ... \$2.00
Stiff cover for filing the leaflets ... \$0.50
- No. 6 "The Uses and Control of Natural Undergrowth on Rubber Estates"
by W. B. Haines (published July 1934) (out of print)
Binder cover for filing the Manual ... \$0.50
- No. 7 "Rubber-Growing—Elementary Principles and Practice"
(published February 1938) ... \$0.50

(b) BULLETINS

- No. 1 "Natural Coagulation of Hevea Latex"
by A. S. Corbet (published September 1929) (out of print)
- No. 2 "A Study of the Effect of Damp Storage on Raw Rubber"
by B. J. Eaton and R. G. Fullerton
(published October 1929) ... \$1.00
- No. 3 "The Root Disease Problem on Old Rubber Areas in Malaya"
by A. Sharples and A. R. Sanderson
(published November 1931) ... \$1.00
- No. 4 "Summary of Meteorological Records, Soils Division"
by W. B. Haines (published December 1931) ... \$1.00
- No. 5 "Variations in the Composition of Latex from Clone and Seedling Rubber"
by J. L. Wiltshire (published July 1934) ... \$1.00

(c) JOURNAL OF THE R.R.I.

Vol. 1	Nos. 1, 2—two numbers combined	(published 1929)	...	\$1.00
Vol. 1	" 3, 4	(published 1929)		
Vol. 2	" 1, 2, 3, 4	(" 1930)		
Vol. 3	" 1, 2, 3	(" 1931/32)		
Vol. 4	" 1, 2	(" 1932)	each number ...	\$0.50
Vol. 5	" 1, 2, 3, 4	(" 1933/34)		
Vol. 6	" 1, 2	(" 1935)		
Vol. 7	" 1, 2	(" 1936/37)		
Vol. 8	" 1, 2	(" 1937/38)		

(d) ANNUAL REPORTS

from 1928	each ...	\$1.00
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(e) INFORMATION CARDS

dealing with various phases of Rubber
Estate Factory Practice and Defects in Raw
Rubber (published February 1934)

in Malaya ...	\$0.50
outside Malaya ...	\$1.00

Bank commission should be added to outstation cheques.



THE RUBBER RESEARCH INSTITUTE OF MALAYA

STAFF

at the 31st December, 1937

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Soils Chemist	...	...	A. W. J. DYCK, Ph.D. (McGill), M.A. (Sask.)
Asst. Soils Chemist	...	...	K. S. PILLAY, B.A. (Madras), F.C.S.

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Asst. Manager	...	...	T. N. DICKSON, A.I.S.P.
Assistant	...	...	R. F. HARLEY

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Edited by H. J. Page on behalf of the Board of the
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